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1) Citrus fruits under irrigation
MNS# PSt SNPaAg231.1

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Diseases of the American horse, and cattle and sheep
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3) Mayhew, Edward
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MNS# PSt SNPaAg231.4

Author:

Title: Citrus fruits under irrigation

Place of Publication: Scranton

Copyright Date: 1914

Master Negative Storage Number: MNS# PSt SNPaAg231.1

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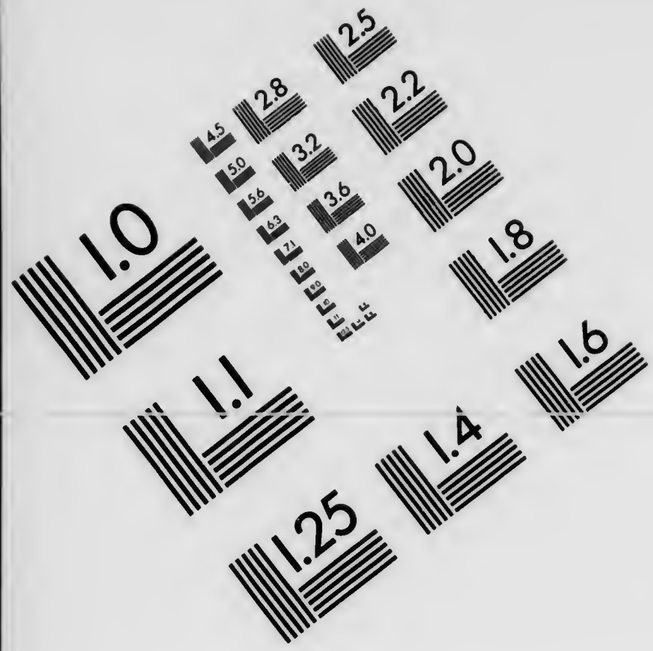

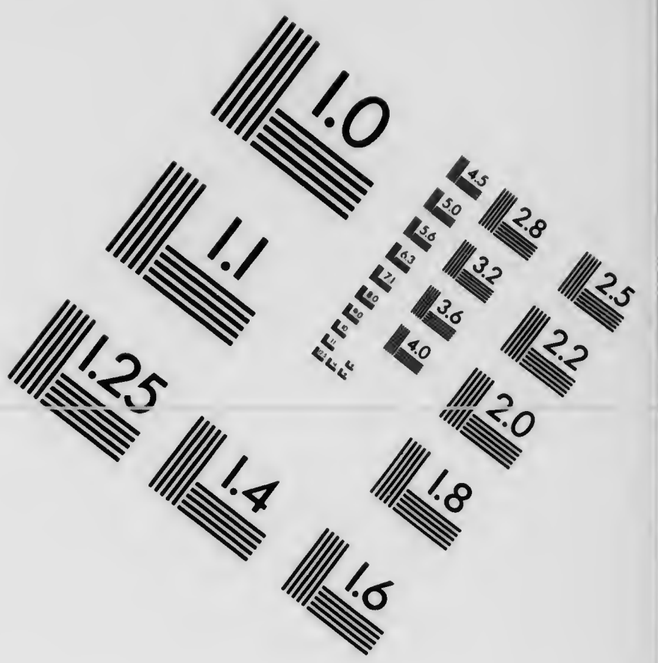

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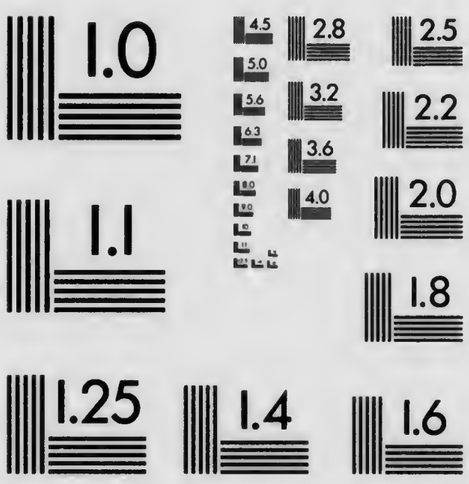

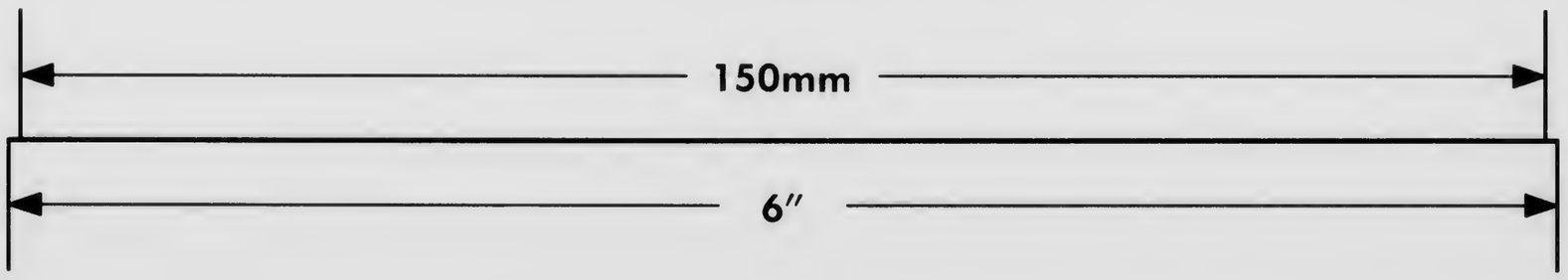

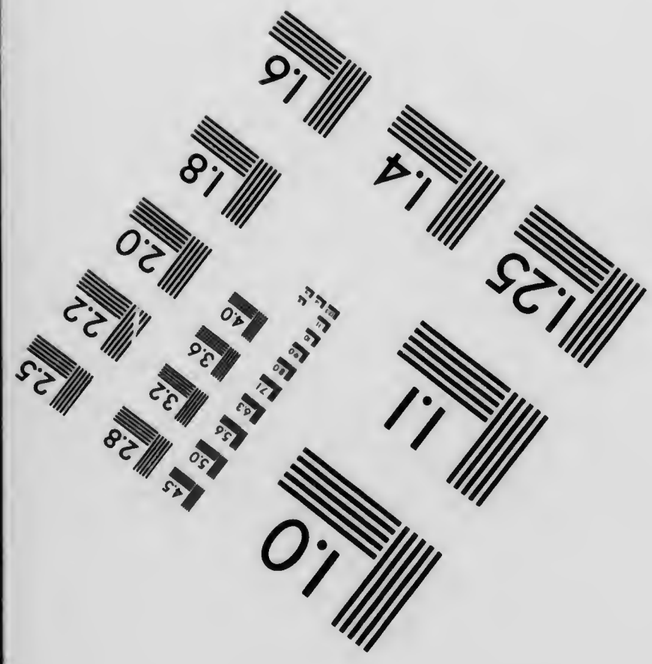

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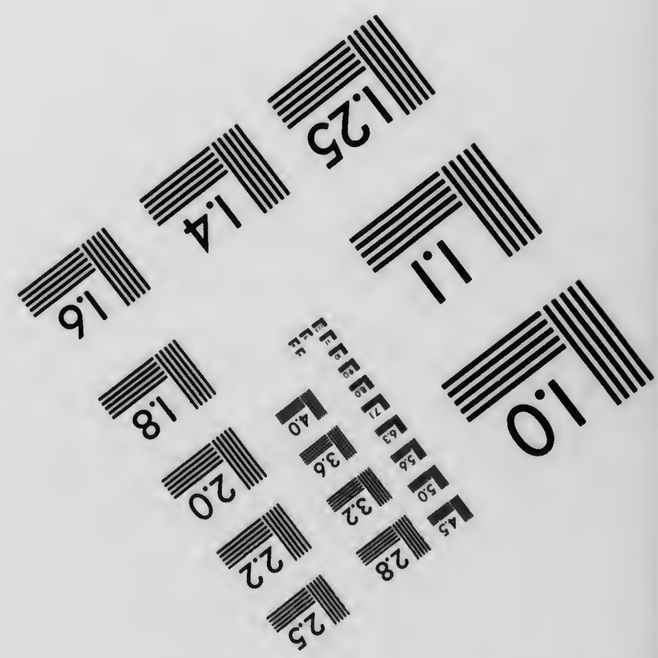

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CITRUS FRUITS UNDER IRRIGATION
CITRUS FRUITS IN GULF-COAST STATES

SCRANTON:
INTERNATIONAL TEXTBOOK COMPANY
127

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INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.

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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the

indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one to select the proper formula, method, or process and in teaching him how and when it should be used.

In the present volume, the commercial production of citrus fruits, including oranges, lemons, grapefruit, limes, and citrons, in all parts of the United States is treated from the standpoint of both the beginner and the practical grower who is already engaged in the business. This work is unique in that it not only considers the subject of commercial citrus-fruit production under irrigation in the citrus-fruit sections of California and Arizona but also where irrigation is not necessary, as in the Gulf-Coast States, which include the citrus-fruit sections of Florida, Alabama, Louisiana, Mississippi, and Texas. The information contained in these pages has been compiled from the experiences of a large number of practical citrus-fruit growers and nurserymen and from the results of experiments and investigations of the state agricultural experiment stations in the citrus-fruit states and of the United States Department of Agriculture. All the phases of commercial citrus-fruit culture are concisely and completely covered. The varieties of each of the citrus fruits grown in each section of the country are described and their characteristics noted. The selection of nursery stock, the many important details connected with the selection of a location for and the planting of a citrus-fruit grove, and the tillage, irrigation, pruning, handling of cover crops, fertilization, protection of citrus-fruit trees from their many pests by means of spraying, fumigation, etc., the budding over of trees, the picking, grading, sorting, and packing of the fruit, and a full description of the citrus-fruit injuries and pests and their methods of control are considered in detail. Special attention is paid to the most modern methods of protecting citrus fruits from frost injury.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part, when the subject is divided into two or more parts, is complete in itself; hence, in order

to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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CITRUS FRUITS UNDER IRRIGATION

(PART 1)

INTRODUCTION

1. By the term **irrigation,** as used in the Sections treating of citrus fruits under irrigation, is meant the artificial watering of land in regions where the annual rainfall is light, and not the watering of soil in humid regions where water is sometimes applied artificially for the purpose of supplying moisture during an occasional drought. In the United States the growing of citrus fruits under irrigation has reached its greatest development in the southern part of California, south of the Tehachapi Range of the Sierra Nevada Mountains, comprising the counties of Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego. In recent years citrus growing on a commercial scale has become important in Tulare, Kern, and Fresno counties in the San Joaquin Valley, and in Butte, Glenn, and Sacramento counties in the northern part of the state. The first mentioned of these smaller districts is often spoken of as the Central California citrus section, and the second one as the Northern California citrus section. In addition to these areas in California, citrus culture under irrigation is practiced in two districts in Arizona. These are the Salt River Valley and the Yuma Mesa districts. The former comprises the larger acreage, and it is rapidly becoming of considerable importance commercially.

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(PART 1)

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2. The citrus fruits grown in California are the orange, the lemon, the pomelo, or grapefruit, the lime, and the citron. The orange ranks first in importance, the lemon second. The growing of lemons is increasing rapidly, however, especially where climatic conditions are favorable. Pomelos are grown to a limited extent only; few plantings of limes and citrons are to be found. In Arizona oranges are the principal citrus fruit produced, although small quantities of the other kinds are grown for home use.

3. Much of the citrus fruit of the West is handled by cooperative associations that are organized primarily for the business of packing and distributing the product of the groves. An association is composed of a number of growers who are incorporated, and the business is managed by a board of directors and officers. Usually the association owns or leases a packing house, where the fruit is prepared for shipment. The association, in a general way, controls the time of delivery of the fruit by the owners at the packing house, and also the quantity that each member shall deliver at one time. In this way the gross quantity of fruit received at one time is regulated, and an overstocking is prevented. In addition to packing and distributing the fruit, professional pickers hired by the associations will, if the growers desire, pick the fruit and deliver it to the packing houses.

Besides the citrus fruit handled by associations, a considerable quantity is marketed by the growers themselves. There are also firms that pack, distribute, and sell the fruit on commission, and some firms buy fruit from growers by the pound, or they pay a lump sum for the fruit of a grove on the trees.

4. In recent years citrus-fruit growing has been very profitable, and there is good reason to believe that it will continue to be so. At times the different sections have been visited by injurious frosts, but these occur only occasionally, and as better methods of fighting frosts are being perfected each year, the damage from this source is likely to decrease in the future. Many groves have in the past been planted on sites not well adapted for citrus growing, and some have not received the

proper care and attention. Such groves, of course, never yield profitable crops. But those groves that are in desirable locations in respect to frost, soil, water, and other such conditions, and that receive the proper scientific culture, are almost sure to remain a source of income to their owners.

5. Citrus groves in the West are variable in size. The 10-acre unit is the most common, although there are many 5-acre units; numerous groves of 15, 20, or 25 acres are found; a few growers have from 100 to 200 acres; and a few corporations have from 250 to 3,000 acres. A 10-acre unit is a desirable size for one man and a team to care for; with another horse and the help of a hired man occasionally a man can care for 15 or 20 acres, and not have much more money invested in such equipment as harrows, plows, wagons, etc., than if he had a 10-acre unit, but as citrus groves either in full bearing or even young groves coming into bearing are expensive to purchase, fewer 15-acre and 20-acre units are found than those of 10 acres.

ORANGE CULTURE

VARIETIES OF ORANGES

6. Several varieties of oranges are grown in California and Arizona, but only two, the Bahia, or Washington Navel, and the Valencia Late are of much commercial importance. Certain other varieties, however, are worthy of trial, in a small way commercially. In home groves it is well to plant several varieties in order that a succession of fruit may be had during a large part of the year. In the subsequent pages, both the commercial and the home varieties are described.

7. The most important commercial orange of California is the **Bahia**, more familiarly known as the *Washington Navel*, and also as the *Riverside Navel*. In 1870 the late William Sanders, of the United States Department of Agriculture, received an importation of navel oranges from Bahia, Brazil.

Soon after, two trees propagated from the original trees by Mr. Sanders were sent to Riverside, California. After coming into bearing they attracted much attention from growers, because the fruit seemed to be especially adapted to California conditions. The variety soon became very popular, and at the present time it is the most extensively planted and most popular variety of its season both in California and in Arizona. Statistics show that about three-quarters of the oranges produced in California are of the Bahia variety.

The Bahia trees make a moderate growth; the heads become well rounded; the foliage is dark, glossy green, and small thorns are present on the branches. Under irrigation the variety is a heavy and a regular bearer and fruit can be expected the third year from planting, often the second year. The fruit is of large to very large size, rounded in form, and somewhat tapering toward the apex. The rind is smooth, tough, and leathery, and from $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness. The color is orange or orange yellow and the fruits are marked at the apex with an umbilicus of greater or less extent. This is a small, irregular secondary orange imbedded within and sometimes slightly protruding from the segments of the fruit.

The Bahia is a seedless variety; the oranges have a rich, vinous flavor and a well-blended acidity and sweetness. The fruit ships well and commands a good price on the market. In Arizona and in Central and Northern California the season is from about November 20 to January 15; in Southern California the season is from about January 1 to May 1. The shortness of the season in the early-producing districts is accounted for largely by the desire of the shippers to get their fruit out of the way before the Southern California crop is ready.

A group of oranges of the Bahia variety is shown in Fig. 1. The navel marking and seedless character are very apparent in the illustration.

The Bahia orange often produces branches which are sports. The fruit of some of these branches is better than that of the regular Bahia, but often it has much poorer qualities. At various times sports of the Bahia have been propagated and

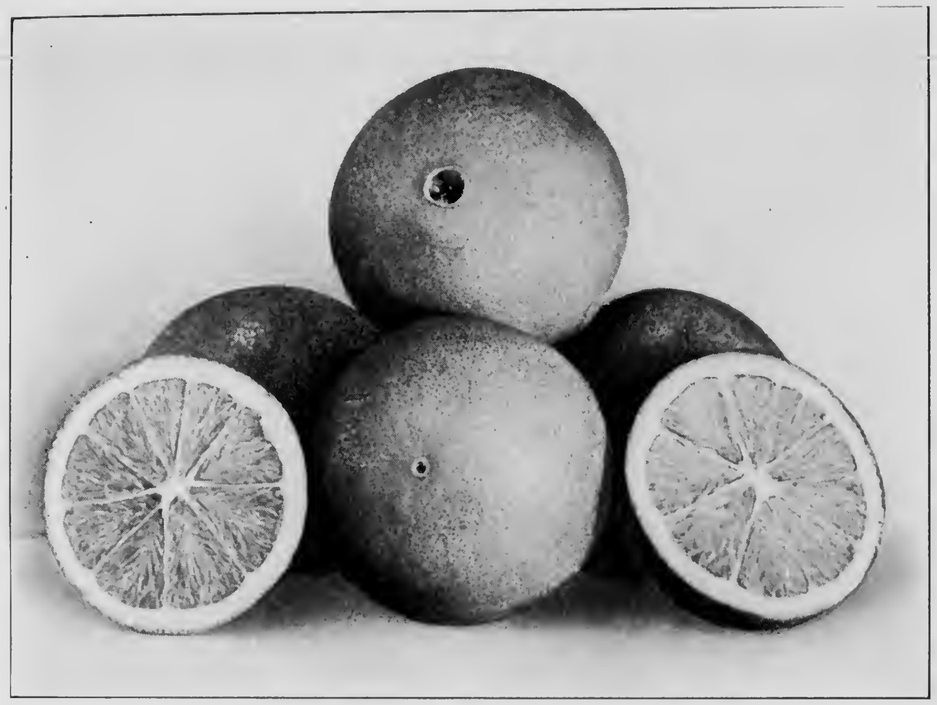

FIG. 1

FIG. 2

offered for sale. At present there are four, the *Golden Buckeye*, the *Golden Nugget*, the *Navelencia*, and the *Thomson*, listed in nursery catalogs.

The Thomson is considered to be the best of these new varieties. It was first distributed by A. C. Thomson, of Duarte, California. The tree is siimlar to its parent. The fruit is of medium size, with a thin, smooth, fine-textured rind, the rind often being spoken of as having a texture like that of a kid glove. The navel markings and seedless property are similar to those of the Washington Navel. The pulp is juicy and sweet; the oranges are solid and good keepers and good shippers. Its season is early, in most sections being somewhat earlier than that of the Washington Navel. This makes the Thomson a desirable Christmas orange.

8. The **Valencia,** or *Valencia Late*, as stated previously, is another important commercial variety of orange grown in California. Aside from its good qualities, its real commercial value is due to its season, the fruit being ready for market after the main crop of navels has been sold, and the supply continues until late in the fall. It is on the market at a time when there is scarcely any competition from other orange-producing sections.

The trees show a fine and vigorous growth, and are slightly more rampant than those of the Washington Navel. They come into bearing early and are notably prolific. The fruit is of medium size, and is solid and heavy. The shape is slightly oval; the skin is rather thin and of strong texture; and the flesh is firm, crisp, and of fine grain; the fruit has abundant juice, an excellent flavor, and but few seeds. In Northern and Central California the season is from March 1 to July 1, and in Southern California the season is from June 1 to as late as December 1 in some years. The fruit is a good shipper and is in season during the summer and autumn months.

Fig. 2 shows a group of California-grown Valencias. Many of the characters described are apparent in the illustration.

In the hot interior valleys the Valencia is likely to turn green again in the summer. In Orange County, and other cool

districts near the coast, this does not occur, and consequently the Valencia is somewhat better suited to these districts than to the interior valleys.

9. The **Ruby** is a variety of blood orange that is grown to a limited extent in California. The trees are vigorous, nearly thornless, and bear with marked regularity. The fruit is

Fig. 3

medium size, round in shape, and of a deep orange color, which becomes reddish when the fruit is mature. The flesh is fine-grained, yellow or orange early in the season, becoming streaked with red in midseason, and when fully mature the pulp becomes a ruby red. The flavor is said by some to be like that of a strawberry. This variety is one of the best blood oranges for culture in California. Fig. 3 shows a group of oranges of this variety.

10. The **Malta Blood** is a variety grown in a small way in California. The tree is a slow grower, a heavy bearer, and the fruit is inclined to be borne in clusters on terminal shoots. A cluster of Malta Blood oranges is illustrated in Fig. 4. The fruit is small, slightly oval, and generally seedless. The pulp is splashed with red and, if the orange is grown in the sun, may be entirely red. The fruit of this variety is ripe just about the time the picking of navel oranges is finished.

FIG. 4

11. The **Mediterranean,** or *Mediterranean Sweet,* is not largely planted in California, although the variety does well in the state. The tree is low, spreading, and thornless. The fruit is medium in size, oval in shape, and has a slightly thickened skin. The quality, as the name indicates, is good. The season is about the same as that of the Valencia. A group of Mediterranean oranges is shown in Fig. 5.

12. The **Paper Rind,** or the *Saint Michael Paper Rind,* is an orange that is grown in many home orchards and to a slight extent in commercial orchards in California. The tree is vigorous, of dwarfish habit, and has light thorns. The fruit is small, roundish to oval, heavy, and solid. The skin is smooth and very thin, sometimes pitted and of a pale orange color. The pulp is fine grained, juicy, and of excellent flavor. The season is slightly earlier than that of the Mediterranean Sweet. The quality is of the best. A cluster of the fruit is shown in Fig. 6.

13. The **Satsuma,** an orange of the Mandarin group, is well adapted to California conditions, but it is not grown extensively in the state for the reason that there are better marketable varieties that can be grown. The tree is very dwarf and nearly thornless; it comes into bearing early and is very hardy, being the most resistant to cold of any of the edible oranges. The fruit is oblate, or flattened, in shape and medium in size; the

FIG. 5

rind is about $\frac{1}{8}$ inch in thickness and is inclined to be roughened. The rind and segments part freely, and the pulp is juicy and sweet. The pith is open, and the sections are frequently separated at the inner edges. The fruit is generally seedless, although occasionally a few seeds are present. In Central California the oranges are ripe by October or November. This variety is well adapted to the colder parts of the southeastern

citrus-producing section of the United States; in fact, it is the only commercial orange in certain sections of that region.

14. The **Dancy,** or *Dancy Tangerine*, an orange of the Mandarin group, is grown to a limited extent in California both for local trade and for shipment to Eastern markets. Although

FIG. 6

much of this fruit is shipped out of the state, it is generally sent East in combination car lots with other varieties. The tree is compactly headed and rather upright. The leaves are much smaller than those on the Navels and Valencias. The fruit is flattened and small. The color is a deep orange-red, almost tomato red; the skin is shiny, free from flesh, and separates

readily from the pulp segments, and, like all oranges of this class, the segments part freely. The fruit carries from seven to twenty small seeds. The pulp is juicy, aromatic, and of a rich flavor. The oranges ripen in January, or later, and are much in demand for Chinese holiday trade.

15. The **Willow-Leaved Mandarin** orange is grown in a limited way in California, often in dooryards for ornamental purposes. The tree is a compact grower and forms a dense shade; this and the golden color of the fruit make the variety especially desirable for ornamental planting. The fruit is

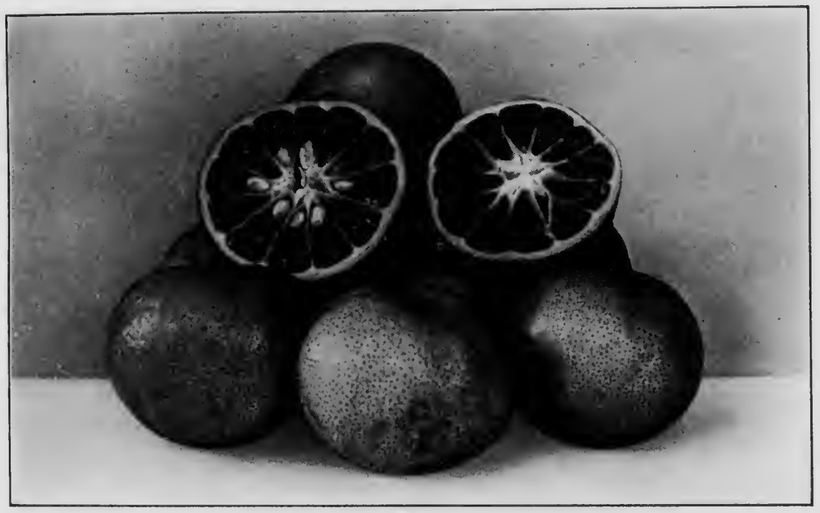

FIG. 7

flattened, small, of a deep yellow color, and has a thin skin that can be removed easily from the pulp. The segments are loosely adherent; the flesh is a dark orange-yellow color and has a spicy and aromatic flavor. A group of this variety is shown in Fig. 7. The loose character of the segments and the thickness of the skin are easily seen in the illustration.

16. The **King** is a variety of the Mandarin group that has been planted in a limited way in California. The tree is upright, is a strong grower, and has dark-green foliage. The fruit is large and oblate in form. The color is orange-red, and the skin is somewhat roughened; nevertheless the appearance of

the fruit is very good. The pulp is juicy, meaty, of excellent flavor, and, as in the other varieties of this group, the skin separates readily from the pulp. The season in California is from June until August, or sometimes even later.

17. The **kumquat** group of oranges contains two principal varieties: the *Nagami*, or oblong, and the *Marumi*, or round.

FIG. 8

The kumquat is native to China, where it is known as Kin-Kan, which means gold orange. The name kumquat is from the Chinese.

The **Nagami** is usually from 2 to 6 feet high, and, no matter how small it may be, is always shaped as a tree and never as a bush. The leaves are dark green, glossy, and lanceolate; the fruit is small in size, being on an average about $1\frac{1}{2}$ inches through the apex and about 1 inch in transverse diameter; the color is golden yellow; the rind is smooth, aromatic, and spicy; the juice is acid and rather sparse. The fruit has from two to five seeds. The season is from January to August in California. The whole fruit, rind and pulp, is generally eaten raw. A cluster of the Nagami variety is shown in Fig. 8.

The tree of the **Marumi** variety is similar to that of the Nagami, but it is slightly more thorny and the leaves are somewhat smaller and rounder at the apex. The fruit is spherical, averaging about $1\frac{1}{4}$ inches in diameter. The rind is thin and

spicy and there is a sparse amount of pulp, as in the oblong variety. The season is from January until midsummer.

The kumquats of both varieties are extremely resistant to the effects of cold. In most instances they are grown in tubs and are moved about on porches and in formal gardens. As ornamentals they are much prized, and in the West are usually grown as such.

SELECTION OF LOCALITY AND SITE

SELECTION OF LOCALITY

18. One of the first factors to consider in selecting a locality for citrus culture under irrigation is whether or not water for irrigation purposes has already been developed, and, if not, whether there is a supply available for development. Without sufficient water for irrigating the groves, citrus growing in California and Arizona is impossible.

Freedom from an excessive amount of frost is a climatic factor that should receive due consideration. All the citrus-growing sections of the West are more or less troubled with frost, but some seem to have fewer killing frosts than others. As the frosting of fruits and trees is one of the conditions that orange growers must contend with, it is well to find a locality, if possible, where there has seldom been much loss by reason of frost.

The price of land planted to citrus fruits or suited to the growing of them should naturally receive consideration. In the older established sections, especially if the land is near growing towns or cities, the price for planted groves will naturally be much higher than the price for planted groves in newer sections; also, unplanted land in the older sections is higher priced than in the newer sections, because there is a greater demand by growers to locate in a well-established citrus-fruit section.

Factors in addition to those mentioned, such as the chance of development, the amount of capital to be invested, the shipping facilities, and the kind of roads to the shipping station, should naturally receive attention when deciding on a locality.

SELECTION OF SITE

19. After the locality has been decided on, the selection of the site becomes important. Numerous factors will have an influence, and all should receive very careful consideration before the site is definitely decided on; a mistake in choosing the place to plant a grove will often doom the success of the enterprise before a fair start has been made. Among the factors that must receive attention may be mentioned the supply of water for irrigation, the type and condition of the soil, the liability of the site to frost, the prevalence of pests, the exposure of the grove, the distance of the grove from the packing house, and the kind of roads over which the fruit must be hauled.

20. Water for Irrigation.—When choosing a site for a new grove or when purchasing an established one, the water conditions should be examined very carefully. The quantity of water needed for irrigating will vary according to the size of the trees, the type of soil, the climatic conditions, and the amount of rainfall.

In California and Arizona there is in vogue the custom of using the miner's inch as the basis of measurement for irrigation water. **A miner's inch** is the quantity of water flowing in a certain time through an orifice of specified dimension under a specified head. Unfortunately, the miner's inch has not a fixed value, since both the size of the orifice and the head vary in different localities. It is thus necessary to qualify this term, in order that it may not be misleading. In case the orifice is taken as 1 inch square and the head as 4 inches, the discharge, or miner's inch, will be approximately .025 cubic foot per second, or 1.5 cubic feet per minute. This would be equivalent to about 16,160 gallons in 24 hours.

Since the early mining days of California the miner's inch has been the unit of measure, but there has been much confusion because this unit had no fixed value in the state. On March 23, 1901, the legislature of California passed a law which made the miner's inch equivalent to $\frac{1}{40}$ of a cubic foot of water per second. This would represent a flow of 11.22 gallons per minute. Many water users in California, however, still adhere to the value of the old miner's inch, which is equivalent to $\frac{1}{50}$ of a cubic foot per second, or 8.98 gallons per minute.

Near the coast each 10 acres of citrus trees in full bearing should be provided with about $1\frac{1}{4}$ miner's inches a day; in hot, interior valleys, and especially on gravelly soils, 10 acres should have not less than 3 miner's inches a day. In a month each 10-acre grove should have from 40 to 90 miner's inches, depending on where it is located. These requirements are based on the miner's inch as fixed by the legislature of California. As it is impossible to irrigate groves daily with so small a stream as that furnished by from $1\frac{1}{4}$ to 3 miner's inches, the accumulation of water is practiced, and instead of getting the quantity of water required every day for a month, the grower gets the accumulated number of inches for the month in one day. In case there is a shortage of water, the individual grower receives a proportionate share of the water from the company.

The rainfall in the California citrus-producing districts varies from 7 to 30 acre inches annually, and, of course, the amount in any section influences the quantity of water needed for irrigation. The rain comes in winter only, and hence it is always necessary to irrigate during the other seasons.

21. In irrigated districts, land is generally sold with a given number of shares of water stock, but, unfortunately, a share of water stock does not mean the same quantity of water in all sections, nor even in the same section when supplied by different companies. With most companies, however, a share of water stock represents the water right for 1 acre of ground, but it does not always mean the same quantity of water. For example, suppose a water company is organized consisting of different men who own a total of 5,000 acres of land. They agree that the basis of the distribution shall be at the rate of 1 miner's inch of water per day for 30 days, or its equivalent, 30 inches for 1 day, to each 5 acres of land. They would require, therefore, 1,000 inches of water. The company is formed with a stock of 5,000 shares, one share to each acre; the stock is sold

to the members of the company according to the number of acres each owns. Suppose, further, that they proceed to develop their water system, and that after the company has developed its water resources, it is found that the water measures only 800 instead of 1,000 inches. Obviously, each 5 acres then must receive its proportionate share of the 800 inches, which, in this case, is $\frac{4}{5}$ of an inch a day, or 24 inches a month.

Suppose, again, that an association is formed for the development of irrigation water; that it has, say, 10,000 acres of land, and that it has found that by tapping a stream it can deliver 3,000 miner's inches of water. If, in the 10,000 acres, there are 2,000 5-acre tracts, each will receive its proportionate share of the 3,000 inches of water, which is $1\frac{1}{2}$ inches a day, or 45 inches for 30 days.

22. From the two examples, it is plain to be seen that a share of water stock in one place or from one company is not necessarily the same as in another place or from a different company. The prospective purchaser should be sure that the quantity of water available for a given area of land is ample for citrus-grove irrigation. It is well for him to spend considerable time in the locality where he thinks he may purchase and study local water conditions there carefully. By talking with growers living in the immediate neighborhood he will learn many facts that may contribute much toward the future welfare of his grove. It can safely be said that if a plentiful supply of water is not available, it is unwise to locate in the region, no matter how desirable it is from other standpoints. When buying a grove it is well to examine the irrigation system on which it depends for water. These systems are kept up by assessments on the water stock, and cases have been known of persons offering groves for sale just previous to a heavy assessment that is issued to raise money for such improvement as relaying a pipe line or mending a drain, without mentioning the assessment to the would-be purchaser.

23. Type and Condition of Soil.—In California, oranges are found growing on about every type of soil in the state. This does not mean, however, that all types of soil are suited

to orange culture. Undoubtedly, the best soil is a deep, rich, easily worked loam. Such soil, with the right care and culture, will maintain a tree in good condition while it is developing and after it is mature. A deep, rich, loam means not only a large storehouse of fertility, but a soil that will take and retain large quantities of water. These conditions are necessary for the best growth of trees and the production of fruit. Shallow soils should be avoided; they mean a smaller zone for the tree roots, and when amply irrigated they are often the cause of a wet, sour, soggy condition a few feet below the base of the tree. In fact, where orange trees have been planted on soils underlaid near the surface with a hardpan impervious to water, trees have been dug up only to find their roots imbedded in mud.

Another type of soil to avoid is one that is apparently good on top, but is underlaid with a stratum of sand or open gravel. Such soils allow water to pass through them quickly, and hence there is a waste of water. Trees on soils underlaid with such porous strata are never satisfactorily productive. A buyer should always dig down into the soil to a depth of 6 or 8 feet, and examine all exposed depths critically, and, as soils are extremely variable, this should be done at five or six places on a 10-acre block.

A free, easily worked loam is undoubtedly the best type of soil for oranges, but they can be made to succeed on light or heavy soils. Still, when planted on either of the two latter types of soil, very careful irrigating and other cultural methods are necessary. For example, on light soils, especially if the subsoil is light also, more water for irrigation and more organic matter for humus will be necessary than on a deep, loamy soil, and on heavy soils greater care must be exercised as to the time cultivating can be done; if a heavy soil is cultivated too soon after having been irrigated, lumps will be formed and the texture is likely to be spoiled for a whole season.

Although in irrigated regions the soil is naturally dry and water must be supplied in order to produce plant growth, soil drainage is sometimes necessary. In the case of a soil that has been too plentifully supplied with water by irrigation, especially if underlaid near the surface with hardpan impervious to water,

a drain to carry off the surplus water will often prove beneficial. In addition, leakage from irrigation ditches, if allowed to continue for a long time, is likely to wet the near-by soil to such an extent that drainage may become necessary.

Soils carrying considerable alkali should be avoided for citrus trees. Alkali is rarely met with in typical citrus districts, however, for the reason that low-lying flat lands, the type most subject to alkali, are nearly always subject to too much frost to permit of profitable citrus culture.

24. Prevalence of Frost.—The orange, being a tropical, or, at least, a semitropical plant, cannot stand much frost without injury to the fruit and the trees. A temperature of about 24° F., if long continued, is very likely to do some damage; hence, in trying to find a site for a grove, it is well to ascertain, if possible, whether or not this or a lower temperature has been reached in past seasons on the piece of land in question. Even in the same locality, certain spots seem to be more sheltered than others. They may be protected by ranges of hills from prevailing cold winds, or they may be on slight elevations where air-drainage conditions are especially good, or they may be in coves surrounded on two or possibly three sides by hills where all conditions seem to operate to make them warm. Such sheltered spots are naturally very desirable for citrus fruits. It is impossible, however, to tell, even in the most sheltered spots, just how low a temperature may be experienced, but it is well when selecting a site to find one that in the past has been comparatively free from damaging frosts.

25. Prevalence of Pests.—An orange grower will learn that there are many pests to combat, among them insects, fungi, squirrels, gophers, etc., but he will learn also that some sites are freer from pests than others, and, therefore, that a big item of expense can be avoided by selecting a site as free as possible from pests. For example, a grove free from scale of any kind will mean no fumigation, but one badly infested with scale or one on the windward side of a badly infested grove is likely soon to become infested, and this means an expense of from $25 to $40 per acre annually for fumigation.

A grove near virgin land or near some grain field is more likely to be troubled with rodents than one that is in the central part of a large area planted to citrus trees. Although most of the pests that trouble orange trees can be combated successfully by employing modern scientific methods, it is well for a prospective grower to get a place where pests are few.

26. Exposure of Grove.—The exposure of a grove should come in for some attention. Side-hill land usually has better air drainage and therefore is likely to be more nearly frostless than land that is flat or in pockets. The grove should not, however, be too high on a side hill, for cultivation will then become expensive, and, in addition, if water for irrigating is pumped by the owner of the land, which is sometimes the case, the irrigating expense must be considered.

Just which slope is the best for citrus culture is a question on which growers do not agree. Many advocate a south slope on account of its being warmer. This is likely to be true if hills or mountains rise to the north and keep off prevailing cold north winds. Others advocate a north or northwest slope, claiming that as the sun does not strike such an exposure so early in the morning as it does a south or a southeast one, the trees and fruit, in case there had been a slight frost, would thaw out slowly and probably be damaged less.

Although side-hill land may have some advantages, gently sloping or even level land often makes an excellent site for an orange grove. If such land is protected from cold winds by near-by hills it may be as desirable as hilly land on account of lessened expense for irrigation and cultivation.

In selecting a site, whether on a side hill or on level ground, the effects of excessive winds must be considered. Not only are they often harmful on account of the cold air they carry, but they do much damage to the fruit and trees. If a tree loaded with fruit is subjected to a strong wind much of the fruit will be scarred and must then be sold at a low price or discarded altogether. In addition, heavy winds cause much damage to foliage and branches.

27. Distance From Packing House.—As the fruit from the different groves must be hauled to a packing house, it is

well, when selecting a site, to get as near as possible to the packing house, providing, of course, the other influencing factors are desirable. A long haul with the oranges loose in boxes means, besides the expense for transportation, some bruised fruit, which in turn means decay of the fruit in transit. The condition of the roads over which the fruit must be hauled is obviously a factor of importance. A poor road between the grove and the packing house adds to the expense of transportation, and, in addition, means much bruised fruit.

SELECTION OF NURSERY STOCK

PROPAGATION OF ORANGES

28. Citrus fruits may be propagated by budding, by seeds, by grafting, or by cuttings. Budding is by far the most common method in citrus districts. Seeds are sown for stocks, and buds of the desired varieties are then worked on these stocks. The propagation of the trees from seed is not resorted to as much as formerly, although in the past many groves were planted in this way. Grafts or cuttings are never used for propagation in a commercial nursery.

A seedling of any citrus variety will serve as a stock on which to bud any variety of citrus fruit desired, but nurserymen in the West, as a rule, make use of only three citrus varieties as nursery stock. These are the common sweet orange of Florida, the sour orange of Florida, and the pomelo, or grapefruit. These are known among nurserymen and growers as sweet stock, sour stock, and pomelo stock. In California, most of the early plantings of budded trees are on sweet stock. Such trees make a greater growth than those on any other stock, and do well, as a rule, except when planted on soils where *gum disease*, which is described in another Section, is likely to occur. Trees budded on sour stock seem to be more resistant to gum disease than those on sweet stock; this is especially true when the trees are planted on rather heavy soil, and for this reason the sour stock is preferred in localities where the disease is prevalent. Nurserymen

of California have of recent years budded on sour stock about 75 per cent. of the trees sold. The pomelo is beginning to be used to some extent in California and is promising as a stock for lemons on gravelly or granitic soils.

Citrus trifoliata, a deciduous orange, is used as a stock in California for dwarf, or potted, citrus trees. This stock is used very largely in the Gulf-coast citrus region, but for grove use it is not recommended for California and Arizona.

29. The general method in use for securing the seed for stocks is to allow the fruit to rot, pulp it in a barrel, and, after washing out the juice and what pulp will flow away with the water, pass the mass of material through a sieve with a mesh fine enough to hold the seeds. The seeds are then thoroughly washed and any adhering pulp removed. When washing the seed, it is a good plan to remove any that do not sink; the small, imperfect seeds are likely to float on the surface of the water and the plump, desirable seeds to sink.

The seeds of the sweet orange or of the pomelo should be kept moist until planted. This can be accomplished by placing them in moist sand at a temperature too low for germination, or in water; the water should be changed frequently to avoid souring. Seeds of the sour orange are not injured by moderate drying. Usually they are dry when received in California from Florida dealers.

When only a small number of seedlings is desired they are usually grown in flats. These flats can be made any size, but if they are over 6 or 7 inches deep and 2 feet square they become heavy and hard to handle when filled with soil. The ends are made of $\frac{3}{4}$-inch stuff; the sides and bottom are $\frac{1}{2}$-inch material. Cracks $\frac{1}{4}$ inch wide are left in the bottom to provide for proper drainage. The flats are filled with a good loamy soil to a depth of 5 or 6 inches and the seeds are sown rather thickly on top of the soil in rows 3 inches apart, and about $\frac{1}{2}$ inch of coarse soil or sand is placed over the seed and moistened. After the seedlings are above the ground they are thinned to stand $2\frac{1}{2}$ or 3 inches apart in the rows. In case a good loam soil cannot be had, a good substitute can be made by mixing sand

with soil until a good loamy texture is secured. The flats may be kept in the house, or, if the weather is warm enough, may be placed outdoors. In the latter case, some protection from the cold at night and the direct sunshine during the day must be provided. Cotton cloth suspended on stakes about a foot above the plants or a lath house that provides half shade can be used to protect the growing seeds and plants. When the seedlings are about 6 or 8 inches high they are transplanted to the nursery row.

30. Large quantities of seedlings cannot be economically grown in flats, and, therefore, when seedlings are wanted in quantities, they are planted directly in the ground, usually under lath shelters, although where the nursery is in a warm, sheltered spot they are sometimes planted in the open with no protection. Seed is planted in the ground in the spring after the soil has become thoroughly warmed. The seeds require a liberal amount of moisture for germination and abundant plant-food for growth. For these reasons great care should be taken to make a good, deep friable seed-bed. The soil should be a free-working loam and it should be spaded to a depth of at least 12 inches and made smooth and fine at the surface.

There are two methods of arranging seed-beds. One is in blocks separated by walks of sufficient width to allow a man to pass around the blocks with a garden hose for the purpose of watering the plants, which is done by sprinkling. The second method is to plant them in beds about 12 inches wide that are separated by 8-inch irrigation furrows. These narrow beds are elevated about 2 inches above the irrigation furrows. These furrows should be made so that the water will flow through them slowly in order to soak under the beds.

The seeds in the blocks are usually sown broadcast; in the narrow beds they may be sown broadcast or planted in rows. Whether sown in blocks or in the narrow beds, the seeds should be placed rather close together, and after the seedlings appear if they become too spindling some should be thinned out.

The seeds are placed on top of the soil and then covered first with about their own thickness of soil and then with about $\frac{1}{2}$ inch

of sifted sand. The seeds require sufficient water to start germination and to keep them growing steadily, but not an excessive quantity; too much water will cause them to decay in the ground. The exact number of irrigations will depend, of course, on local conditions. Many nurserymen irrigate every two weeks for two or three times after planting and then every month during the summer. Irrigation should not be continued too late in the fall, for the young trees must harden their wood before cold weather, and this they will not do if kept too moist.

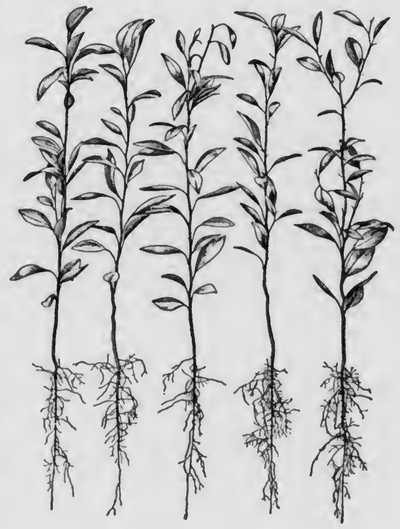

FIG. 9

31. For protecting the plants from cold and excessive sunshine, when protection is deemed necessary, most nurserymen use what is known as a lath house. A house of this kind used as a packing and storing shed is shown later in Fig. 13. Lath houses for packing and storing purposes are similar in construction to seed-bed houses, the difference being that the latter always have flat roofs. The houses are made of plaster lath with the space of a lath between laths. The ground is thus half shaded. Cheaper shade can be made by driving rows of stakes in the ground and stretching wires from one to another of these stakes, and then stretching muslin or burlap from wire to wire to form a sort of tent.

Most of the seedlings will appear in about 3 weeks from planting, but some may not appear for 4 or 5 weeks. With good care in the matter of weeding and irrigating, the plants should be about 1 foot high the following spring, a year from planting. Fig. 9 shows a lot of 1-year old seed-bed plants. When the plants are about 1 foot high they may be transplanted to the nursery row, or, if thought desirable, left to grow for another year in the seed-bed. If the young plants vary much in size

the first year, the larger ones should be transplanted and the smaller ones left to grow for another year. These smaller plants, after the thinning out of the larger ones, will have a good opportunity for growth during the second summer, and will therefore be likely to make strong, stocky plants when ready

FIG. 10

for transplanting. Fig. 10 shows a lot of 2-year-old seed-bed plants. The greater stockiness and better root development of these over the 1-year-old plants will be very apparent by a comparison of Figs. 9 and 10.

32. Some of the roots will be injured in the transplanting process. In order to preserve the proper balance between the

tops and the roots it is necessary that the top and branches be cut back in proportion. Nurserymen do this top pruning before digging the plant; a pair of hedge shears is used for this purpose. From 25 to 50 per cent. of the top is removed, the exact amount depending on conditions. If the transplanting is done early, when there is plenty of moisture in the air, it is not necessary to remove more than 25 per cent. of the top, but if it is done late, from June to August, when evaporation is greater, 50 per cent. should be removed.

33. Just before young seedlings are transplanted to the nursery row, the ground in which they are growing should be thoroughly sprinkled, in order that as few roots as possible will be broken off in taking out the seedlings. The bed is then spaded to loosen the roots, and the seedlings are carefully pulled out with the hands. If all the seedlings are not removed from the bed, the ground around those that remain is sprinkled again, so that they will settle back to place.

After being taken up, the seedlings are sorted into two lots, according to size, and the ends of the tap roots are cut off, so that they will not double up in the hole when the seedlings are planted. The tops are also trimmed back to correspond with the roots. The trimming is done with a hatchet, a bunch of from twenty-five to fifty seedlings being trimmed at one time. The seedlings are then packed in damp moss and placed in boxes to be hauled to the nursery row.

All plants showing gumming and those with bench roots should be discarded. A bench-rooted tree is one which has an S-shaped bend or crook in the main tap root a few inches below the surface of the ground. These crooks often take the shape of very acute angles and the sap flows around them with considerable difficulty. The cause of bench roots has not yet been discovered, athough a good deal of experimenting has been done. It is probably due to the position of the embryo within the seed. There are always a certain number of bench roots in any given lot of seed-bed stock, and, as stated, these should not be planted.

The ground for the nursery should be well chosen. A mellow, easily worked surface soil and a heavier subsoil furnish ideal

conditions for the growth of nursery stock. In case the surface soil is made up of a large percentage of clay and is inclined to bake, the texture can be improved by growing some legume, such as alfalfa, the year before the young seedlings are set. This cover crop can then be plowed under, which will tend to improve the texture of the soil and at the same time supply a certain quantity of plant-food. Ground used for a permanent nursery bed should always have some kind of a leguminous cover crop sown just as soon as trees have been removed from a block.

34. Ground must be thoroughly plowed, leveled, and smoothed before seedlings are planted. The soil should be as uniform in texture as possible throughout its entire depth, and the ground should be staked off in rows at least 4 feet apart. This distance is necessary, in order to allow ample room for horse cultivation without breaking off the buds and branches. The seedlings are placed from 12 to 18 inches apart in the rows. Closer planting is likely to make the trees too small in size, and it does not leave enough space to cut out a ball of earth with the trees when they are sold. The method of balling the trees is described later.

In order to space the trees at uniform distances use is made of a length of wire and a marker. The marker consists of a wheel to which crosspieces of wood or iron are fastened at regular intervals around the rim. The wire is fastened to the posts at both ends of the row and the wheel is pulled or pushed along the wire. The crosspieces on the rim make marks on the soil at regular intervals where the trees are to be planted.

A dibble or other sharp tool is used to make a hole where the tree is to be planted; the tree is set in place, and the earth pressed firmly about the roots. The soil at the time of planting should be fairly moist—neither too wet nor too dry.

The tree should be placed in the ground about $\frac{1}{2}$ inch above the height it stood in the seed-bed. This $\frac{1}{2}$ inch allows for settling, after which the tree will stand at the heighth it stood in the seed-bed. The irrigation water should follow down the rows as they are being planted, in order that the plants will get

a start immediately. Soon after the rows are planted they should be gone over and all plants which, on account of their small size were not cut back by the trimming hatchet when they were removed from the ground, should be cut back in proportion to the others. If this is not done these small plants are likely to die.

35. During the summer and fall following planting, the plants should be cultivated and irrigated frequently enough to keep them in good condition. Cultivation must be clean and thorough and should follow directly after the nursery has been irrigated. Cultivation must cease early enough in the fall so that the wood may ripen and be in a hardened condition before cold weather sets in.

The sprouts that form up to about 5 or 6 inches above the ground during the summer should be pinched back. The tops will need practically no pruning, except for the removal of a broken branch occasionally.

36. If the seedlings have made a good growth they should be ready for budding the fall or the spring following transplanting. If they have not made a good growth, it will be necessary to allow them to grow until the next fall or spring before budding. If spring budding is practiced, it should be done early, just as soon as the bark will slip sufficiently to allow the insertion of the bud. This will be sometime in March or April. Spring budding is sometimes done as late as June, but conditions must be favorable to get good results from such late budding. For California conditions, fall budding is preferable to spring budding, because, if the trees have been budded successfully, the buds will start growth with the first flow of sap in the spring, and, as a rule, they will have one or two more growths than a spring-budded tree. Most stock in California is budded in the fall for these reasons. The time for fall budding varies with the variety, the condition of the weather, and the growth of the plants. It ranges from September to December. *Citrus trifoliate* stock is budded early in September. Sweet stock, pomelo stock, and sour stock is usually budded later, but all budding must be done before the bark becomes tight on the stock.

Wood from which buds are taken is known as budwood. Rigid care should be taken that no mistake is made in the identity of the tree from which the budwood is taken. If budwood is to be taken from several different trees, that from each tree should be tied with waxed string in little bundles and carefully labeled. Soft-wood labels are preferable, since the indentation will remain in the wood if the label is written with a hard pencil. Ink should not be used for labeling, since it blurs when wet and the writing is often hard to distinguish. Budwood should be taken from well matured wood of not more than one season's growth. It is usually best to select wood from the last one or two growths matured just before the time of cutting. Almost any bud, small, immature, or growing may be used and made to grow if it has the proper care. For propagation work, however, any buds that require nursing should be avoided and for this reason only the stronger, well-matured buds should be used. Buds from diseased, unthrifty and unproductive trees should be avoided.

37. The so-called **T** or shield budding is practiced for citrus trees. In the West, the transverse incision is made at the top of the longitudinal incision; in Florida, it is made at the bottom. Waxed strips of cloth or string are used for tying the buds. Some budders cover the bud entirely with the waxed cloth or string; others cover it only in part, as in deciduous budding. Practically no difference is noticed in results. The height that buds are inserted varies considerably in practice. Some budders prefer to bud 9 or 10 inches high; others, particularly on small stocks, crowd the buds close to the ground. High budding is, however, considered to be best, as high budded trees are said to be less subject to gum disease than are low budded trees.

Detailed instructions for the budding of citrus nursery stock are given for Florida conditions in a subsequent Section, and as they are similar for California and Arizona conditions, they need not be described here.

About two weeks after the buds have been placed all the plants should be examined closely to ascertain whether the

buds have united with the stock. If at that time the buds are still green and a line of new tissue has formed around the incisions, it may be safely concluded that a union has taken place and that the bud will grow. The wrapping about the bud is then cut away. If, on the other hand, the buds in some stocks have shriveled and turned brown it is a sure sign that those buds have not united with the stock. Such stocks should be rebudded. If the trees have been budded in the spring, the tops are cut off 4 to 6 inches above the inserted buds a few days after they have united with the stocks. It is necessary to remove the top of a seedling tree above the inserted bud, in order that the sap of the tree may be forced into the bud and thus cause it to make rapid growth. If the trees have been budded in the fall, the tops are not cut off until the following spring. It is desirable to have the buds remain dormant throughout the winter. Sometimes during a warm spell in winter they start growth, or a certain proportion of them do, even if the top has not been removed. Such a condition is not desirable, because these young shoots are very tender and are very easily injured by frost.

Buds that have been inserted in late spring when there is a full flow of sap in the tree must be treated in a different way. It is unwise to cut off the top entirely, directly after the buds have united with the stock, for the buds are not strong enough to carry the full flow of sap at this late season. The practice in this case is to cut about half way through the stock at a distance of about 3 inches above the bud on the same side as the bud, then bend the top over, being careful that the stock does not split downwards and throw out the bud. The tops in a pair of rows should be turned in the space between them, leaving the other alternate rows open for cultivation. The tops can be pegged down with forked sticks. This is known as lopping the tops. This practice enables the bud to adjust itself to its new condition gradually before receiving the full flow of sap from the stock. The top still receives a certain amount of sap, while the bud receives sufficient to force growth and yet not injure it. After the buds have grown to be about a foot or so in length, the bent-over tops are removed. Lopping

the tops is rare in the West, however, because most budding is done in the fall.

38. After the cutting or the lopping of the tops and until the tree is of sufficient height to head, many sprouts will be forced out along the lower part of the stem. These should be pinched back. To insure a straight tree it is necessary to stake the shoot before the bud begins to bend over of its own weight.

FIG. 11

Raffia is suitable for this purpose, as it is cheap and easily handled. After the budded trees are about 18 inches tall, if they are hardy and strong, the stub of the stock above the bud is cut off and the wound painted or covered with some wound dressing. The cut should be made close to the stem.

Fig. 11 shows nursery rows of young budded trees growing in California. Note the straightness and stockiness of the trees.

The budded trees grow until they are about 40 inches or so in height, when the top is cut off. This forces out shoots from which the head is formed. Of late years, the tops are usually taken off about 33 inches from the ground and the heads allowed to form down 9 inches, making the bottom of the head 24 inches

FIG. 12

above the ground. This makes what in the West is known as a low-headed tree. An advantage of such trees is that they shade the trunk when it is young and tender and might easily be damaged by the sun. Also, low-headed trees are less likely than high-headed trees to be injured by winds, and the fruit

can be harvested more readily and cheaply. The advantage of letting the tree grow until it is over 33 inches in height and then cutting it back rather than pinching it back as soon as the height of 33 inches is reached, is that the wood from which the main limbs are formed will be larger and stronger and thus will make a better head for the tree.

Nursery trees ready for heading are shown in Fig. 12. This illustration is from a photograph taken in a citrus nursery in Southern California, and shows straight, stocky, well developed trees, the kind desired for citrus plantings.

39. Citrus trees in the West are usually sold either as 1-year-old or as 2-year-old buds, the age being reckoned from the time of budding. They are graded according to caliper, the measurements being made one inch above the bud.

The grades are usually as follows:

One-year-old buds: Grade 1—caliper, $\frac{5}{8}$ inch and up; grade 2—caliper, $\frac{1}{2}$ to $\frac{5}{8}$ inch; grade 3—caliper, $\frac{3}{8}$ to $\frac{1}{2}$ inch.

Two-year-old buds: Grade 1—caliper, $\frac{3}{4}$ inch and up; grade 2—caliper, $\frac{5}{8}$ to $\frac{3}{4}$ inch.

TRANSPLANTING NURSERY STOCK

40. In case the soil is a good sandy loam, the ground should be irrigated about 24 hours before budded trees are removed from the nursery row for transplanting. If the trees are in a heavy soil, it is necessary to irrigate a day or so sooner. The tops of trees that are to be taken up should be pruned to compensate for the loss of roots that will occur. In practice, this usually consists in removing about one-half of the top. This removal of the tops is generally done while the trees are still standing in the nursery.

41. In the West, two methods are employed for preparing nursery stock for transplanting—the *open-root method* and the *balling method*. In the **open-root method** the trees are dug and the earth removed from the roots by the method employed for deciduous trees. This method is used when the trees are to be planted in the near vicinity. The **balling method** consists of digging up a ball of earth with the roots and wrapping

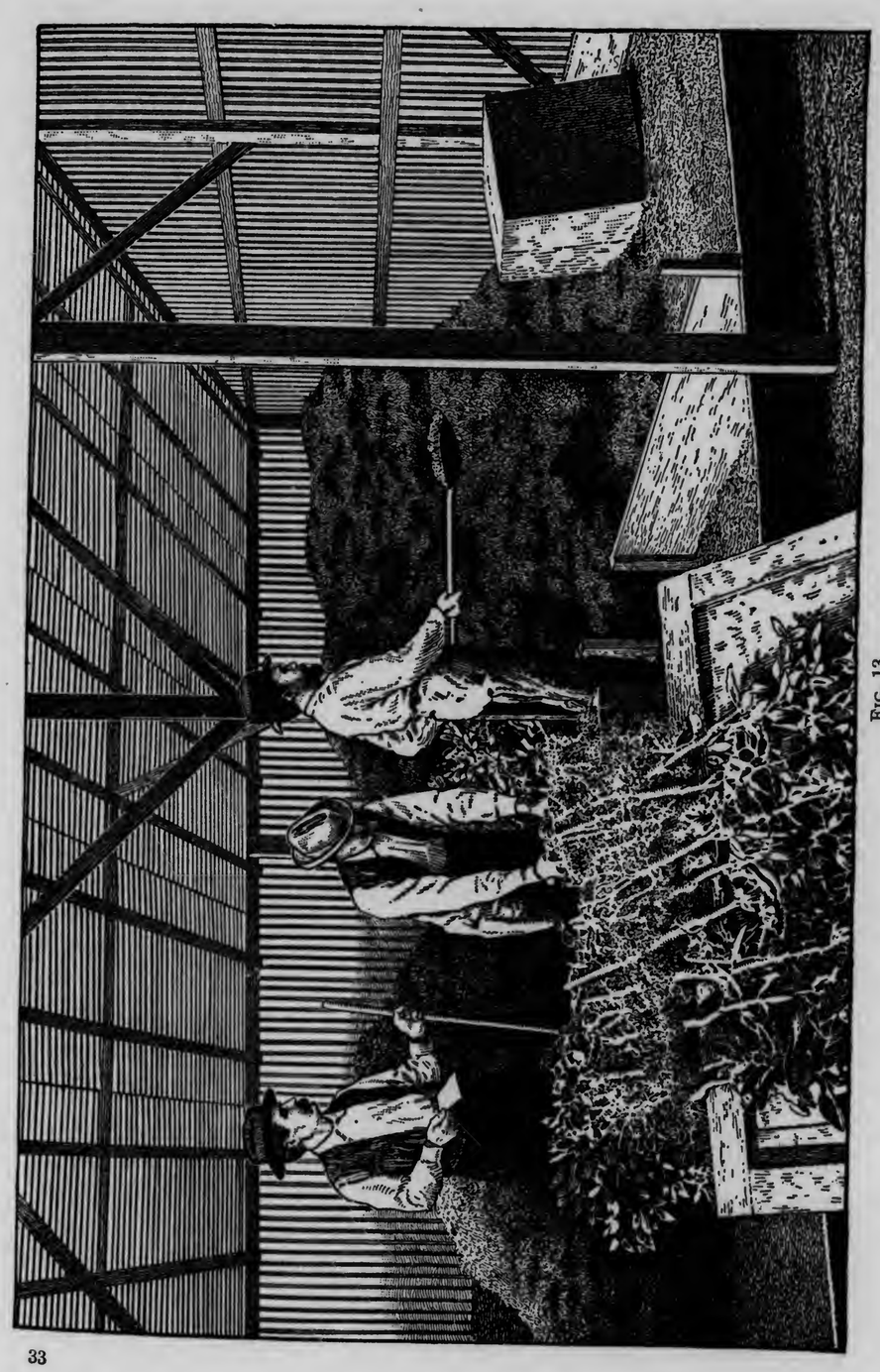

FIG. 13

this earth with burlap or other heavy cloth, thus retaining the earth about the roots. The balling method is more practical than the open-root method for trees that are to be shipped. The ball of earth weighs from 40 to 60 pounds, and, of course, very materially increases freight expense, but balled trees, on account of the roots remaining in earth, seldom wilt or lose their foliage even when shipped for long distances, and this is a reason for their use.

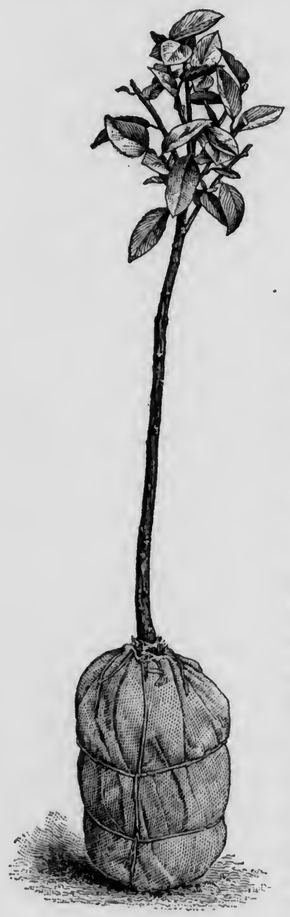

FIG. 14

42. If the open-root method is followed the soil is irrigated and made soft and a trench from $1\frac{1}{2}$ to 2 feet deep is dug along the side of the tree row. The tap root is cut off with a spade, and then the spade is forced down on the opposite side of the tree and the tree pushed into the trench. After the earth has been shaken off from the roots they are covered with wet cloth to protect them from the sun and the trees are carried to the end of the row. It is a good plan, soon after digging the tree, to dip the roots in mud of about the consistency of paint; this adheres to the roots and prevents them from becoming dry. If the trees are to be planted in the immediate neighborhood, they should be taken to their destination at once, the roots being first packed in wet straw and the tops covered with canvas to shield them from sun and wind. If they are to be shipped, the roots should be packed in damp moss and the trees boxed at once.

In Fig. 13 is shown a lath house in which young citrus trees are being packed in moss. In California such half-shade structures are much used as packing and storage places, as they shield the trees from the direct sunlight and also allow the circulation of air.

43. When the trees are to be balled a trench from 12 to 15 inches deep is dug about 5 to 6 inches from the trees, along the row, and the tap roots cut as for open-root planting. With a sharp spade, the one doing the balling cuts around the other sides of the tree, leaving the earth adhering to the roots. The distance he cuts from the tree will depend on the size of the ball of earth desired to be taken up with the plant; as a rule, it is about 4 or 5 inches. After the ball is free, it is lifted out of the hole and the tap root, if it sticks below the dirt, is cut off with a pair of pruning shears. This leaves the tap root from 12 to 15 inches in length. The ball is then placed in the center of a piece of burlap, which is brought up over the sides and top of the ball and wrapped and tied as shown in Fig. 14.

SECURING NURSERY STOCK

44. Whether to purchase citrus nursery trees from nurserymen or to propagate them at home is a problem that confronts the orange grower. There are, of course, arguments in favor of both plans. As may be inferred from the preceding paragraphs, the growing of a citrus tree ready for planting requires a long time, the right soil and climatic conditions, careful attention to details, and considerable knowledge of tree growth. Most growers do not have land available for a nursery, and hence must depend on the nurserymen; and those planting new orchards, unless they are adding to orchards already established, will not care to wait the three or four years necessary to produce the trees. When buying from a nurseryman, it is well to deal with one having a reputation for selling good trees. While chances of getting trees that are not true to name are not as great as in former years, yet it is desirable to secure trees from a nursery where every care is exercised to grow the trees properly. Well-established nurserymen may charge a few cents more for trees, but the few cents difference in price is a small item when the difference between poor and good trees is considered. It does not pay to economize by buying cheap trees. Most dealers give a guarantee to replace any trees that do not come true, but when a grower has waited 3 or 4 years

for a tree to produce fruit and then finds the fruit not of the type or variety he purchased, he has lost much more than the price of the tree, and replacing it is not much of a financial advantage. True, such trees can be budded over to some desired variety, as explained later, but even this means a loss of profit over what would have been made had the trees been true to name.

A nurseryman who is experienced in this particular line of work can often produce better trees than a grower, and his workmen will be more adept in removing the tops and roots, in digging and balling the trees, and, in fact, in all the details of tree production. These facts, coupled with those discussed in the previous paragraph, often make it advantageous for the grower to purchase his trees ready for planting in the grove.

In case, however, a grower is well established and has land available for the purpose and possesses a knowledge of nursery work, he will often find it advisable to grow his own trees. He can usually produce the trees more cheaply than he can buy them, but the principal advantage he gains is that the buds can be selected from the best type of tree of the variety it is desired to propagate. A bud from a good-producing, healthy tree is very likely to be a better bud for propagation than one from a tree that habitually produces meager crops of poor fruit. This is a very important point for a grower to consider. He should, therefore, exercise every care possible in the selection of buds for propagation. The nurseryman who buds thousands of trees cannot, as a rule, give as much attention to bud selection as the grower who buds comparatively few trees. In case a grower does not care to grow trees he can, at least, select his buds and carry them to the nurseryman and have him bud and grow the trees under contract. As the nurseryman has stocks ready for budding, the grower will not have to wait more than one or at least two years for his trees, which is less, of course, than were he to grow the stocks himself. This procedure is often much better than letting the nurseryman select buds, and it has been successfully resorted to by many growers.

PLANTING OF GROVE

45. Selection of Varieties.—In selecting varieties of oranges for commercial planting in the West, it should be remembered that the Washington Navel and the Valencia have proved to be the best varieties for commercial planting. The planting should, therefore, be mainly one or both of these varieties, with perhaps a few others for experiment. Whether to plant one variety or both will depend on conditions. Experience proves that often one of the varieties is better adapted to a certain locality than to another. Therefore, the grower should select the one adapted to his particular locality. A good way to find out about the adaptation of a particular variety to a given locality is to get information from the leading growers of the vicinity. If it is learned that both Washington Navels and Valencias do well in the locality, it is a good plan to ascertain which variety brings in the greater returns, and make the planting accordingly.

46. Time for Planting Trees.—In the irrigated regions of the West, orange trees can be planted at practically any season except winter, but experience shows that spring planting is the best. The soil should be warm in order that conditions for growth may be favorable. Just which month in spring the trees should be set out depends somewhat on the location. At Fullerton, in the southern section of California, C. C. Chapman, one of the most successful growers in the state, regards March as the best time. He states that the trees when set at this time soon start to grow, and that they are able to make a good growth before the winter season. In the Riverside and Redlands sections, the majority of plantings are made in May or June. In the central California section, April, May, and June are considered to be the months for planting, most growers in that section desiring to get them in as early as the weather will permit. In Arizona, April and May are considered by most growers to be the best months for planting citrus trees, although if the season is warm the latter part of March is a good time for planting.

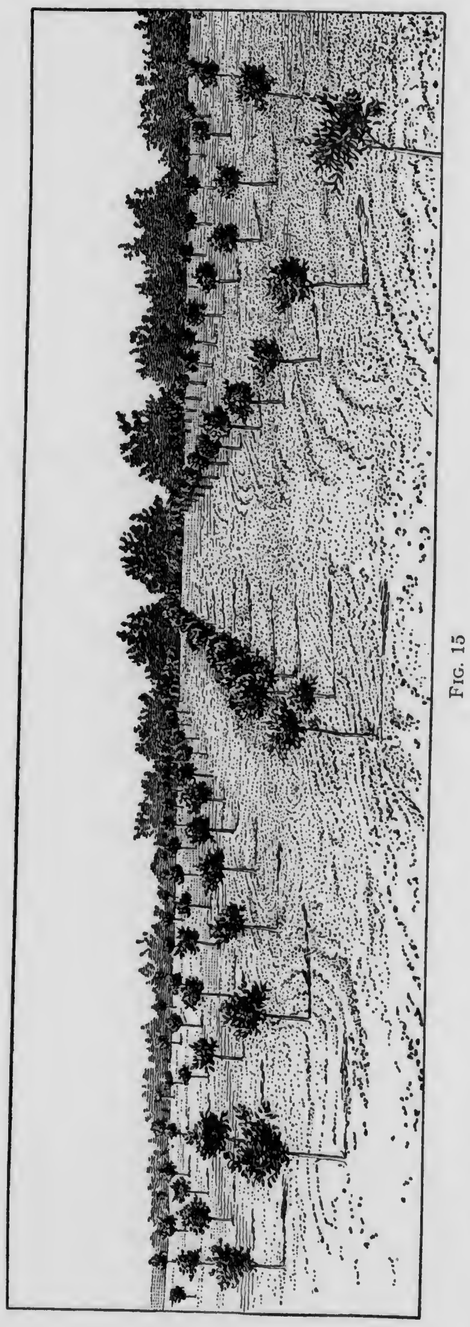

FIG. 15

47. Arrangement of Trees in Grove. In the West, most groves of recent planting are set according to the square system; that is, the distance between the trees in a row is the same as the distance between the rows. In the past, several different systems were used to some extent, but they met with little favor from citrus growers. The square system is considered to be the best, because there is less difficulty in cultivating between the trees, a practice necessary for the success of a citrus grove.

Fig. 15 shows a young grove planted according to the square system. The regular spacing of the trees is apparent from the picture.

If a grove is to be planted on a hillside, it will probably be necessary to run the rows along the contour of the hill. In this respect no set system of arrangement can be adopted.

48. Planting Varieties in Blocks.—If more than one variety of citrus fruits are grown, it is well to plant the different varieties in blocks by themselves on account of the ease of handling the fruit; that is, the Washington Navels are planted by themselves, the Valencias by themselves, and so on throughout the grove. If Washington Navels and Valencias, for example, are mixed throughout the grove, it will be necessary to traverse the area twice in the season when gathering the fruit, since the fruit matures at entirely different seasons.

49. Distances for Planting.—Formerly Washington Navel and Valencia trees were placed as close as 20 feet apart each way, but of late years 24 feet apart is considered about right, although some progressive growers say 25 or 26 feet would be better. Too close planting is not advisable. The chief reason for wide planting is that considerable room is required to handle the tents used in fumigating the trees for combating insect pests. Another reason is that the trees are vigorous feeders and require considerable space for their roots; and, as they have the spreading habit, they will soon grow so near together that the branches will interfere with cultivation, especially if the cultivating implements are run diagonally across the field, as is often a practice. At 20 feet apart each way, there are 108 trees to the acre; at 24 feet, 76 trees; at 25 feet, 70 trees; and at 26 feet, 64 trees.

50. Grading the Land Before Planting.—The land should be smoothed and prepared before the trees are set, so that regularly graded even furrows or basins can be had for irrigation purposes. Uneven furrows or basins cause the water to run fast in one place and slow in another, and, consequently, it percolates to different depths, thus causing some trees to get too much water while others may not get enough. Once the trees are planted, this condition cannot be remedied. Hence, the great importance of a careful grading of the land before planting. This grading, or, as it is often termed, leveling, is accomplished by filling in the low places and removing the high places. The land is plowed and then a scraper is used to transfer the dirt from the higher to the lower places. Fig. 16 illustrates a type of

scraper often used for smoothing land. This implement is known in all Western citrus-producing regions as a Fresno.

The irrigating plan must be very carefully worked out for hilly land and the ground graded accordingly. If a very hilly site is to be used for a grove, benches or terraces are made on which the trees will be planted and along which irrigating furrows will run. If the land is only moderately sloping, the tree rows can be run along the contour of the hill, and the furrows likewise. The furrows must not follow the slope, or there will be much washing of the soil when irrigating.

51. Adding of Humus to Soil Before Planting. Before the advent of water for irrigation in the West, vegetation was very sparse, and, in many cases, lacking. It is only natural, therefore, that the soils of that region are deficient in humus

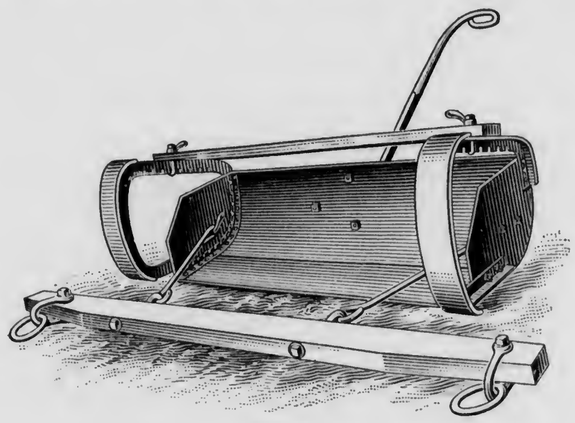

FIG. 16

and consequently in nitrogen. These soils are, as a rule, fairly rich in phosphoric acid and potash, and hence, if vegetable matter is added to them, they become fairly well balanced in fertility. In view of this condition, it is a good plan, before planting an orange grove in the irrigated regions of the United States, to improve the condition of the soil by the addition of humus-making material, especially that which will add nitrogen to the soil. This may be accomplished by growing vetch or some other legume on the land before the trees are planted and turning a part or all of each crop under as green manure.

Rye or some other grain crop can be grown and turned under to form humus, but as grain crops are not legumes, they bring no nitrogen from the air to the soil, as in the case of vetch or some other legume.

Turning under a good application of stable manure is also a desirable method of incorporating organic matter in a soil previous to planting. The manure will rot quickly, and thus humus and nitrogen will soon be available. Where stable manure can be obtained at a reasonable price, this plan is an economical one to follow, as the land can generally be gotten ready more quickly than by green manuring.

A combination of both green manuring and stable manuring is often advisable. By this plan the land may be made fairly rich in humus in one year. It is best that the soil improvement be made after the land has been smoothed and graded for irrigating, for then the humus that is formed will remain near the surface; whereas, if the work were done after the addition of the vegetable matter, the humus would be scraped into the low places, thus leaving many spots lacking this material.

52. Tillage Before Planting.—Just before the trees are set out, the land should be plowed and harrowed and made of as good tilth as possible. The plowing should be deep and the harrowing thorough, so as to leave the ground smooth and fine at the surface. Thorough tillage means an improved condition of the soil structure and texture. The trees, when planted in such soil, will start into growth rapidly and from the start will make stronger and more thrifty trees than if the preparation of the land is not thoroughly done. The need of the right preparation of the soil before planting citrus trees cannot be too strongly emphasized.

53. Locating Trees in Straight Rows.—The boundaries of the ground to be planted should be laid off and the places where the trees will stand staked, before the holes to receive them are dug. The surest method of securing absolutely straight rows in an orchard is to have a surveyor locate the site of every tree with a transit, and this is often done when the question of appearance is of sufficient importance to justify

such an expensive method. In many cases, however, the expense of this method is prohibitive. One of the most convenient methods of securing straight rows in a square planting, without surveying the grove, is to locate the outside rows around the field carefully, and then set a row of stakes with one stake where each tree is to be located, in these rows around the field. If the lines of the field are definitely known, a man's

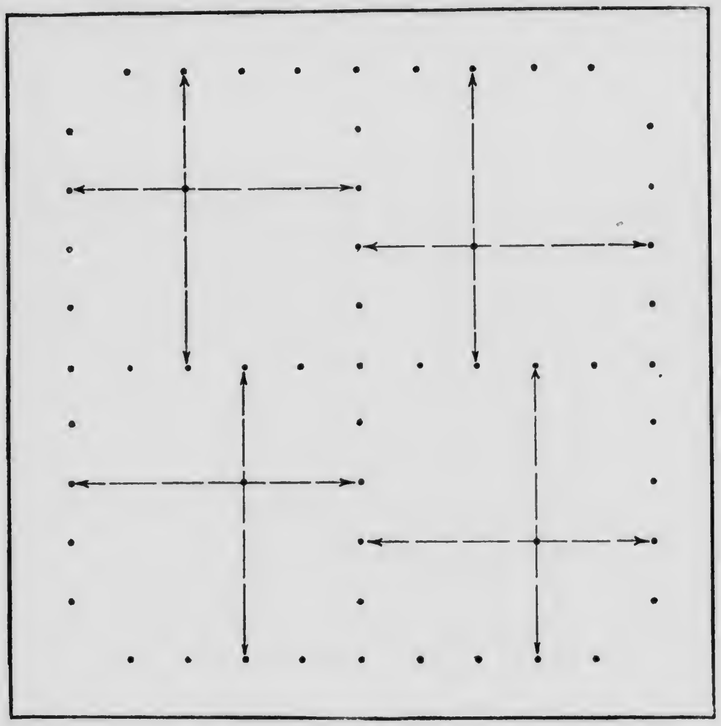

FIG. 17

judgment will suggest a way to get these stakes in the right place. Then through the center of the field, in each direction, another row of stakes is set as shown in Fig. 17.

With a field laid out in this way, there are always two stakes available in two directions for determining the proper location for each tree to be planted. For example, the proper location for a tree may be determined by sighting across stakes as indicated by the lines in Fig. 17. The usual method is to set a peg at the point where each tree should go, as determined by

sighting; but, since the stake must be removed when the hole for the tree is dug, a planting board is often used to get each tree in its proper place. In Fig. 18 is shown a planting board by means of which a tree can be planted exactly where the stake stood originally. The dimensions are marked for

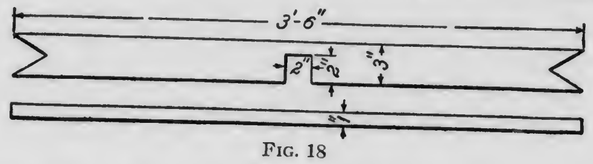

FIG. 18

the convenience of those wishing to saw out such a board. In Fig. 19 is shown the method of using the planting board. In this illustration, for the sake of clearness, the planting board is shown out of proportion to the width of furrow and the distance between trees. In (*a*) the letters indicate as follows: *a* is the irrigating head-furrow, or water supply, at the edge of the field; *b, b, b* are the stakes locating the places where trees are to stand; *c* is the planting board with the square notch at the center in place at the position of one of the stakes *b*; *d, d* are two stakes that are placed in the end notches of the board.

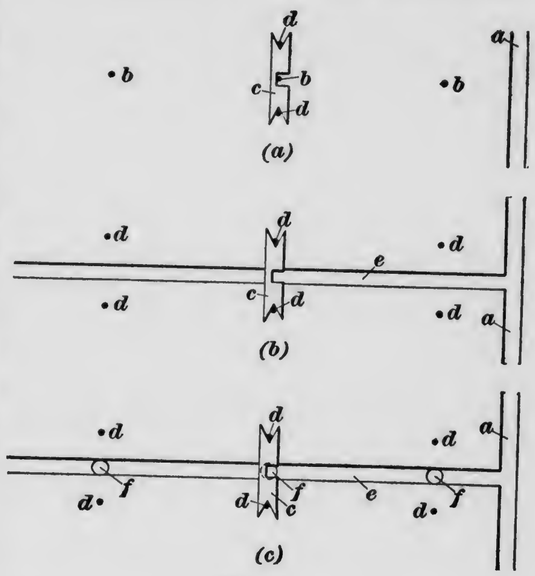

FIG. 19

Assuming that the ground has been prepared and staked, the planting board is placed in turn over each stake where a tree is to stand, two stakes *d* are placed in position as shown in the illustration, and the stake *b* removed. This leaves a row of stakes on either side of where the tree row will stand. An irrigating furrow *e* is then plowed out from the head-ditch

between the rows of stakes *d*, as shown in view (*b*). This furrow is to be used for irrigating the trees as soon as they are in place. Following the making of the irrigating furrow *e*, holes *f* are dug between the stakes *d*, as shown in view (*c*). The planting board is then placed over each set of stakes, and the tree planted so that the trunk occupies the same position on the board as the stake *b* did when the board was placed in position previous to the making of the irrigating furrow and the holes for the trees.

54. Planting the Trees.—The holes for the trees should be made about 3 feet deep, and wide enough to leave room for the spreading of the roots. The holes may be dug with a shovel or blasted out with the aid of dynamite. If the land is inclined to have a hard subsoil it is usually a good plan to use a stick of dynamite in digging each hole. Special tree planting dynamite of 20 per cent. strength can be procured from most concerns manufacturing explosives. The equipment necessary for blowing holes consists of cartridges, or dynamite sticks, caps, cap crimpers, fuse, and a soil auger, or a crowbar. A hole about $1\frac{1}{2}$ inches in diameter is bored in the ground with a soil auger or punched with a crowbar to a depth of 30 to 36 inches. A fuse 2 to $2\frac{1}{2}$ feet long is cut from the roll, squarely across, not diagonally, and inserted carefully well down toward the explosive charge in the cap. When inserting the fuse in the cap it must not be twisted, because the cap may explode. After the fuse is fastened in the charge, the cap is firmly crimped to the fuse by the cap crimper. The paper wrapper at one end of the cartridge is then unfolded and a hole $1\frac{1}{2}$ inches deep is punched in it with a round-pointed wooden punch. Into this is inserted the cap with the fuse, and the wrapper is drawn over the top, around the fuse, and tied with a piece of twine. The cartridge is then inserted in the hole and forced to the entire depth with a wooden stick. A broom handle serves the purpose. After the charge is pressed home, 2 or 3 inches of fine dirt or sand is put on top and tamped very gently with a wooden stick. The hole is then filled with 2 or 3 inches more of soil and this is packed a little more firmly. After the charge is covered to

a depth of 5 or 6 inches the soil may be pressed firmly in place without danger of a premature explosion. The hole is filled even with the surface of the soil. The fuse can then be lighted with a match or any kind of lighter. The fuse burns at the rate of 2 feet per minute, and thus the length used gives ample time for the operator to step back out of danger. The soil will be loosened for a radius of from $2\frac{1}{2}$ to 3 feet and a depression of from 4 to 6 inches made in the center. A hole can be readily scooped out from the soil thus loosened and the tree quickly set in place. The charge can also be exploded by electricity, which is the most practical method if a great number of holes are to be blown. Further details along this line can be secured from companies manufacturing explosives. Great care and caution must be exercised in the use of dynamite, and for this reason it is well for beginners to secure all the information possible about its use from the company manufacturing the product and to follow the rules carefully. Practically all companies manufacturing dynamite supply a handbook giving valuable information concerning the use of explosives. The blasting of holes for trees with dynamite has several advantages over the digging of the holes with a shovel: first, the soil is pulverized for a considerable distance all around and the hardpan is broken so that the soil absorbs water, which enables the roots to take hold on the soil more quickly; second, less labor is involved in setting the trees. It is a fact that trees planted in dynamited soil will show a greater and stronger growth at the end of a season than trees planted in holes dug with a shovel.

55. About 4 or 5 inches of well-rotted manure is placed in the bottom of the hole for the purpose of inducing deep rooting of the tree; above the manure is spread about 6 inches of surface soil. The tree is then placed in the hole, and surface soil with which a little well-rotted manure has been mixed, is pressed about the ball of earth or about the roots of the tree and under them, if the tree is too deep in the hole. The tree should be set so that after it has settled, which will be about $\frac{1}{2}$ inch, it will stand at exactly the same heighth it stood in the nursery, which heighth can be seen by the difference in the color of the bark.

If planted so that it stands lower, the bark, which contains chlorophyl and lenticular clusters of stomates, will be so near the ground that the winter rains are likely to splash spores of the brown-rot fungus on the bark. As a result, the tree may become affected with what is known as the brown-rot form of gum disease. Another effect of too low planting is that the trees do not start into growth quickly, but become stunted. Often it is necessary to raise such trees to a higher level in order to promote proper growth, which adds considerable expense to the cost of the grove. A citrus tree planted higher than it stood in the nursery row will usually start into growth quickly, and will in time develop a satisfactory root system; nevertheless, the appearance of the tree with the surface roots above the ground is not desirable, and in addition, the tree is in somewhat greater danger of drying out in case there is a shortage of water than is a tree planted at the proper height.

In case balled trees are to be set, the cloth is not removed from the roots. Most growers simply cut the string near the top of the ball and push the cloth into the hole; there are cases when the string is not even cut. The cloth will soon decay after it is covered with soil, and as the roots are plentiful and near the surface of the ball of earth, the tree will soon start to grow if sufficient moisture is present.

After the tree is in place, soil is filled into the hole to within 4 or 5 inches of the surface. This leaves a basin in which water collects at the first irrigation. As soon as possible after the trees are set, water is turned into the irrigating furrow shown in *e*, Fig. 19. Besides supplying water to the trees, irrigation settles the dirt in the holes. After the soil becomes dry, the basin about the tree is filled with earth, and any trees that are leaning out of line are straightened and the rows lined up, after which the stakes used to indicate the position of the trees are removed.

TILLAGE OF GROVES

56. Tillage is an important factor in the maintenance of fertility and moisture in the soils of western citrus groves. A principal benefit of tillage is that it supplies and maintains an abundant quantity of air in the soil. Plant roots require air for their proper development; also, air is necessary for the life of the soil bacteria. Tillage operations, in addition, make possible the turning under of organic matter that will form humus; they keep down weeds, increase the reservoir space for soil moisture, and prevent the evaporation of an excessive quantity of moisture from the surface of the soil.

57. Plowing the Groves.—Western citrus groves should be plowed about 8 or 9 inches deep, except on sandy soils, where the depth may be slightly less. It is a good plan to vary the depth an inch each year, as one of the causes which helps to form *plow sole* is plowing to the same depth each year. **Plow sole,** also known as *plowpan,* and as *irrigation hardpan,* is a compacting of the soil below plow depth. This condition is often met in the irrigated regions. At times, the subsoil is so badly compacted that it is almost impervious to water. In soils of very fine grain, a plow sole is more easily formed than in coarse-grained soils. The plow sole layer can usually be broken up by varying the plow depth each year. For example, if the plowing one year is 8 inches it should be made 9 inches the next year, then 8 inches the third year, and so on, alternating the depth each year.

A subsoil plow may often be used to advantage to follow in the furrows made by the regular plow for the purpose of breaking up plow sole. Subsoiling is not always advisable, however, as it prunes many root fibers. One condition where subsoiling is an advantage is in case the trees have been injured by frost and have been pruned back severely. The subsoil plow would not only loosen up the plow sole but would prune the roots commensurate with the pruning of the branches, which is a benefit to the trees.

In the irrigated citrus regions, soil at some distance below the surface will support plant growth practically as well as the

surface soil and will not require weathering for a year or so, as is the case with many soils in humid regions, and thus there is little danger of plowing too deep as far as bringing up subsoil is concerned. However, plowing should not be deep enough to injure many of the tree roots.

Groves are plowed in the spring, usually about March, although if no cover crop is growing on the soil they may be plowed soon after the winter rains are over, which, as a rule, is about the last part of January or the first part of February. Winter cover cropping is practiced to a large extent in the groves of the West, and the cover crop is plowed under during the spring plowing of the grove. If the soil is very heavy, an additional plowing is sometimes made in the summer or the early fall. On most soils, however, spring plowing is sufficient.

58. Both moldboard and disk plows are used in the West for plowing citrus groves, some growers preferring the one

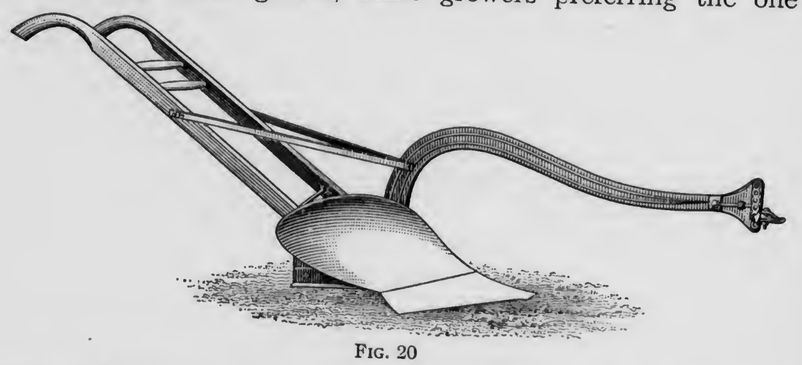

FIG. 20

type and some the other. A 10-inch or 12-inch moldboard plow is a very efficient implement for plowing most of the space between the trees. However, it is usually necessary to make one, and sometimes two, furrows near the trees with a 6-inch or an 8-inch moldboard plow drawn by one animal. In Fig. 20 is shown one of the Oliver G series of moldboard plows, a plow recommended by many of the growers of Southern California. The claims of the manufacturers for this plow are: first, the plows are light in weight, which makes work easy for the operator; second, the plow is built on a steel frog, or frame, thus giving the necessary strength without the usual heavy weight

construction; third, both steel and chilled shares are provided, which makes the plows serviceable in both sticky and sandy land; fourth, the plow is provided with a landside equipped with a removable heel, which lengthens the life of the landside. These plows are made with either an iron beam or a wooden beam. The iron-beam plow is largely used but many growers prefer the wooden-beam plow. If the plow strikes a stone and the beam is broken a wooden beam can be replaced more easily and cheaply than an iron one. Most frequently, also, in

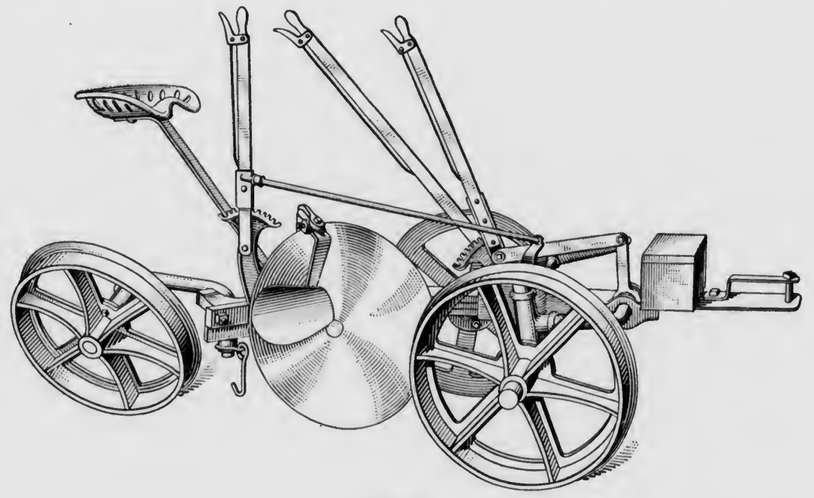

FIG. 21

the wooden-beam plow, the bolts will be simply drawn out of place if the plow strikes a stone and can easily be drawn back in place.

For turning under a cover crop, a moldboard plow supplied with a roller colter is very efficient. This point is explained more in detail in a subsequent Section that treats of cover crops in the groves.

In plowing, and also in all subsequent tillage operations in citrus groves, short doubletrees and singletrees should be used, as they are less likely to injure low-hanging branches than are long singletrees and doubletrees. The placing of leather protectors over the clips is also a wise precaution. Also, for the same reason, all the tillage implements used in a grove

should be provided with tin shields that will lessen injury to low-hanging branches.

An orchard plow of the disk type known as the Newell-Mathews orchard disk plow is shown in Fig. 21. Plows of this kind are made with the wheels set close to the frame, the front furrow wheel is pivoted in order that it can be turned to or from the trees as desired, and the levers used to operate the disk and wheels are placed in the central line of the implement. These parts are so designed for the purpose of avoiding damage to the trees when plowing close to them.

59. Surface Tillage in Groves.—Frequent surface tillage is necessary in irrigated citrus groves from the time the ground is plowed in the spring until a cover crop is sown in the

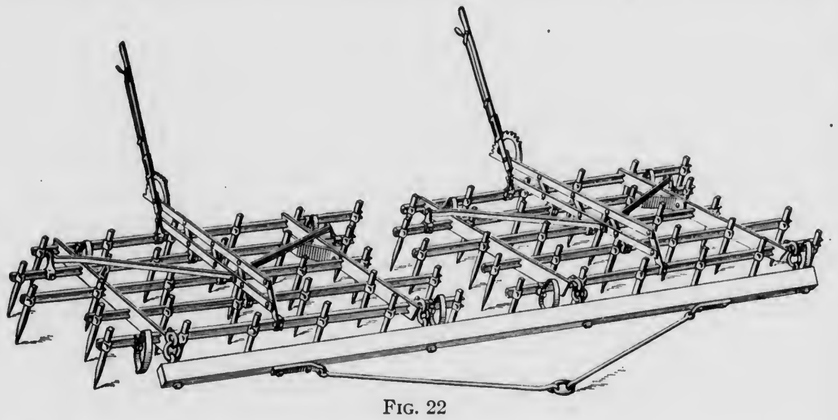

FIG. 22

Fall, if one is sown, or until the rains of winter, if one is not sown. Cultivating the grove once every 2 weeks is none too frequent. In fact, except on fine silt soils, it is almost impossible to till irrigated groves too often. Careful experiments have shown that cultivation to a depth of 5 inches is best for California soils. Harrows and so-called orchard cultivators are the implements used for surface tillage of groves in the West.

60. Harrows of many different types are employed, the exact type to be found in any particular grove depending largely on the personal preference of the owner, on the type of soil in the grove, and on the nature of the work to be done. In Fig. 22 is shown a spike-tooth harrow, which is a type often useful

in fruit-tree cultivation. Spike-tooth harrows may be had with either an iron or a wooden frame, and in one, two, or three sections. The teeth are of iron and do not run to any great depth in the soil. By means of a lever with which each section is provided, any desired slant can be given to the teeth, which arrangement makes it possible to regulate the depth of harrowing. Specially adapted spike-tooth harrows can be purchased for orchard cultivation. These are made in sections that are attached to extension frames and can, therefore, be extended so that the harrow can work close to the tree. The spike-tooth harrow is very efficient for following a plow on cloddy fields and for dragging over irrigation furrows in advance of cultiva-

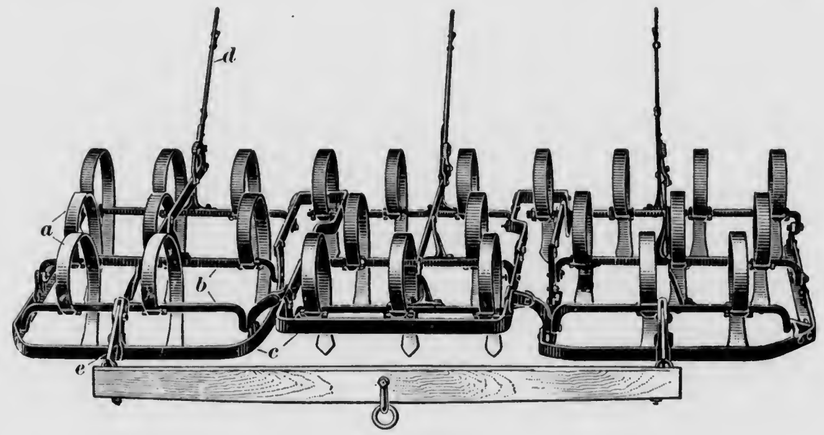

FIG. 23

tion. They are excellent for scarifying the surface of the soil after a crust has formed on the surface.

In Fig. 23 is illustrated a spring-tooth harrow, a type favored in stony soils and in any soils where it is desired to loosen up ground that has become packed. The teeth *a* are flat, narrow strips of steel bent circular. They have tapering points and are bolted to cross-bars *b* fitted into a frame *c*. The teeth are so arranged that no tooth follows in the track of another. These harrows are made in two and sometimes three sections, each being detachable and thus available for use with one horse. Short rods *e* are bolted to each frame and carry a bar to which the hitch is made. By regulating the levers *d* the

harrow can be made to run to any depth desired from 2 to 5 inches. In some cases small iron wheels are placed on the front or at the sides to help regulate the depth.

In Fig. 24 a disk harrow is shown. Harrows of this type are very useful on ground covered with litter of any sort and on ground where a green manure crop has recently been plowed under. At times they are used instead of a plow for turning under a green manure crop. Disk harrows consist of a series of sharp disks mounted in such a manner that they may be adjusted to cut straight ahead or at an angle. The style

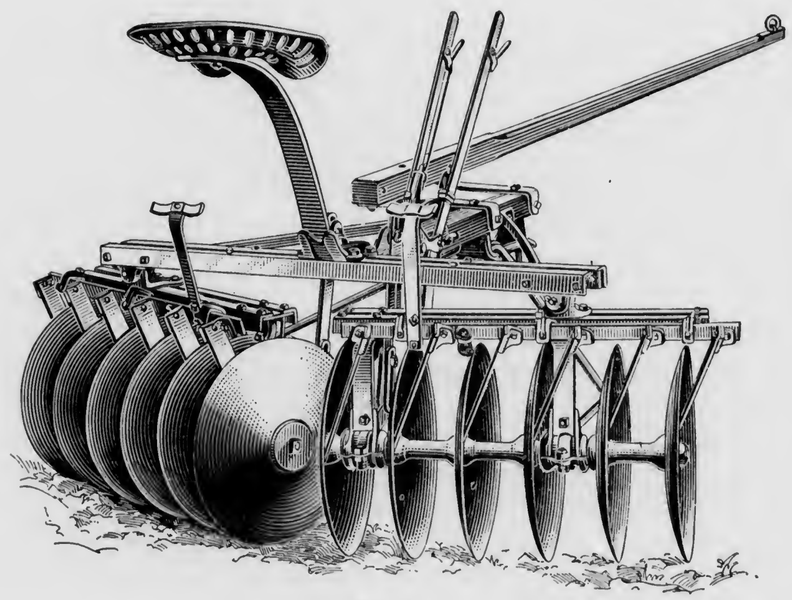

FIG. 24

pictured in Fig. 24 is a single-row disk harrow, as it has but a single row of disks. The levers shown are for regulating the cutting depth of the implement. Fig. 25 shows a double-row disk harrow. The principle of this is the same as that of the single-row disk. The rear row of disks is set to cut between the cuts of the first row, and the implement will do more and better work in a given time than the single-row disk harrow. In Fig. 26 is shown a cutaway disk harrow. This implement differs from other disk harrows only in the cutting edges of the

disks. Disks of this shape cut the soil more deeply than the other. The exact cutting depth can, however, be regulated by the levers.

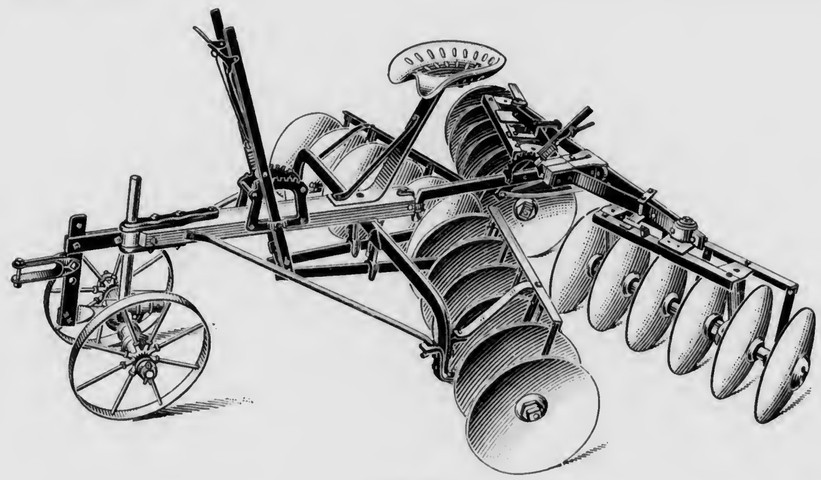

FIG. 25

A disk harrow can be set to work soil to any depth up to 4 or 5 inches. If the disks are sharp, it is very effective on

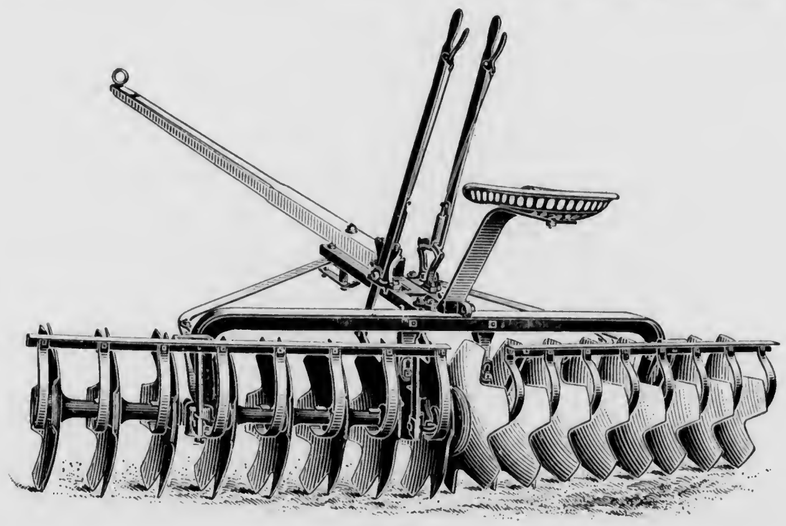

FIG. 26

plowed sod lands. An advantage of the disk harrow over some other types is that it pulls up no manure, straw, or sod that has been turned under by the plow. Many of the disk harrows used

in citrus groves are provided with extension frames like that on the cultivator shown in Fig. 30, so that when desired the ground beneath the branches of the trees can be worked.

61. A cultivator of the type shown in Figs. 27 and 28 is in very general use where deep cultivation is desired in orchards. The Planet Junior and Iron Age machines are examples of this type. When cultivating at some distance from the trees, the seat is attached as shown in Fig. 27, and when cultivating close to the tree trunks the seat is shifted to the position shown in

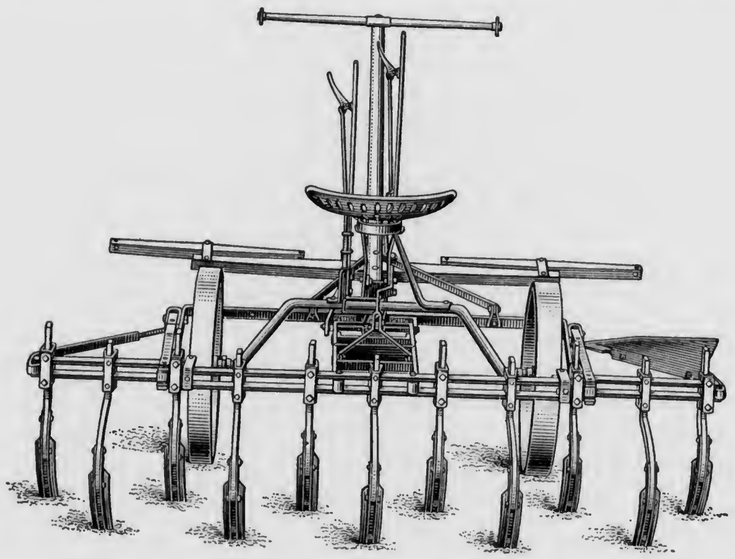

FIG. 27

Fig. 28. Machines of this type are very efficient for loosening up the soil in a citrus grove. By means of the levers the teeth can be set to dig at different depths. At the right of the implement shown can be seen a guard that is for the purpose of preventing injury to low-hanging fruit when the implement is driven underneath a tree. The fruit, instead of hitting against the metal projection of the cultivator, will slide over the guard without injury. It is a good plan, if no such device is on the tillage implement in use, to wire a sheet of tin

over the projecting parts that might cause injury to low-hanging fruit.

A type of cultivator known as the Monarch, which is much used in California groves when deep cultivation is wanted, is illustrated in Fig. 29. This cultivator is designed for heavy work and is especially useful in the heavy types of soil. By arrangement of the different levers it can be carried level or deeper on one side than on the other.

Spading harrows like the one illustrated in Fig. 30 which is known as the Roderick Lean, are used by many California growers for cultivating citrus groves. These implements are supplied with extension frames, as shown in the illustration,

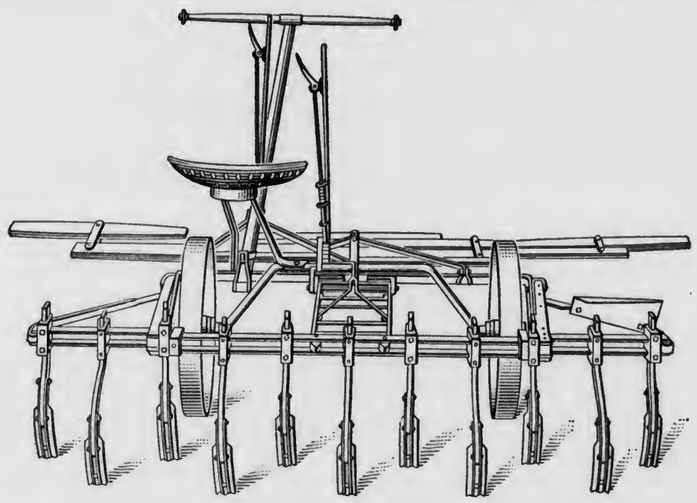

FIG. 28

or they may be used with the parts near together. The depth of cutting is regulated by foot levers, which can be seen in the illustration. The revolving disk-like curved parts of the cultivator are very efficient in stirring and turning over a layer of the surface soil.

In Fig. 31 is shown the Killifer cultivator, an implement that has been used for a long time in California groves. It is designed to loosen and aerate the soil without turning it over. The curved teeth of the implement simply gouge out small furrows in the soil but they do not bring soil from lower depths

to the surface. This is an advantage where soil moisture must be conserved.

62. Tractors that haul the different implements of tillage

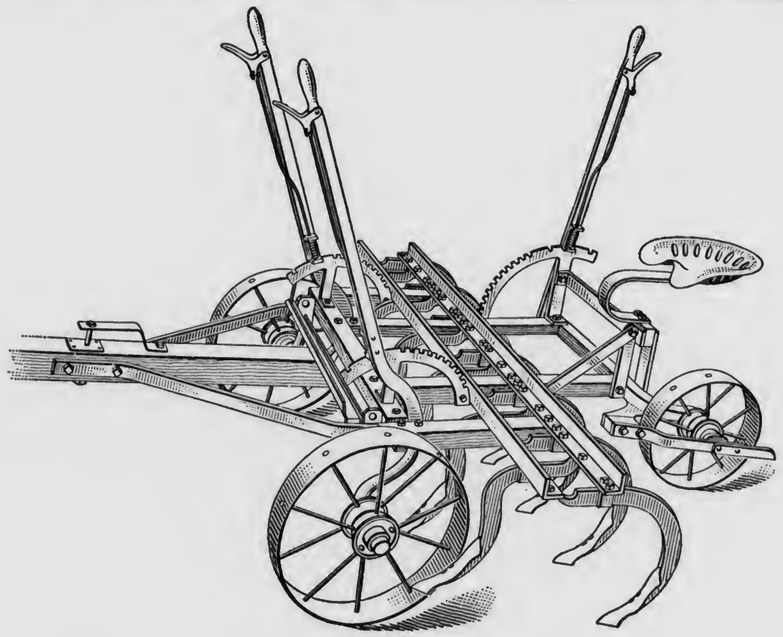

FIG. 29

are found in some groves in the irrigated citrus-producing regions. Where the area to be cultivated is large enough to

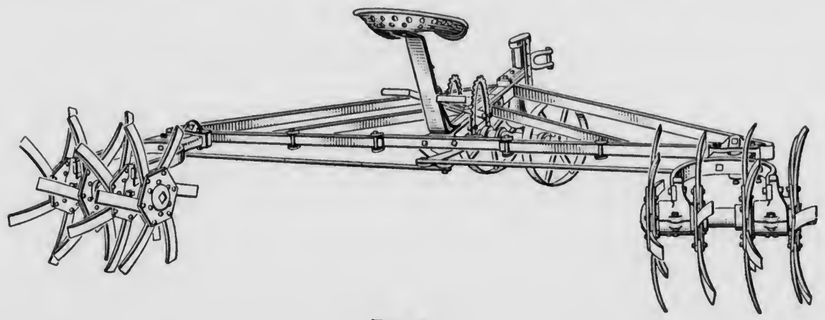

FIG. 30

pay returns on the investment in such machines, they are often found to be more economical for tillage power than horses or mules. Agents for the manufacturers of tractors especially

designed for citrus-grove tillage are to be found in California and Arizona, and often it will pay growers to confer with these

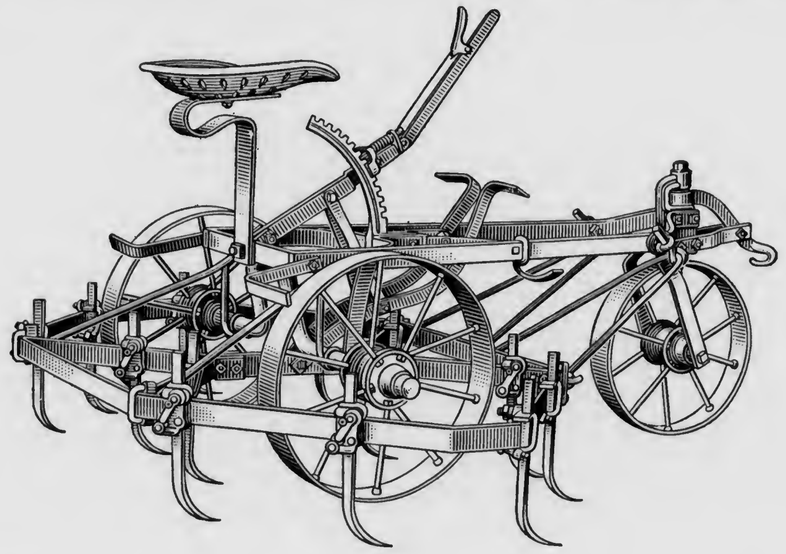

FIG. 31

agents and compare prices of tractors and implements with those of horses and horse-drawn implements.

CITRUS FRUITS UNDER IRRIGATION

(PART 2)

ORANGE CULTURE—(Continued)

IRRIGATION OF GROVES

1. Distribution of Water.—High efficiency has been attained in the distribution of water for irrigation purposes in citrus groves in the West. In the earliest irrigating systems the water was conveyed through the groves in ditches, later wooden flumes were used, and following these, were concrete flumes. In recent years concrete tile or iron pipe laid underground is generally employed for distributing the water.

When the head is not over 8 or 10 feet, concrete pipe, if well made of 1 part of cement to 4 parts of clean, sharp sand, is proving highly satisfactory; when the head is greater than this, iron pipe should be used. The sections of concrete tile are made with a taper at one end and a bevel at the other, and the joints are cemented so that roots cannot grow between them and pry the tiles apart. Tile 12 inches in diameter costs about 35 cents a foot, laid down. The tile is usually laid about 15 inches below the surface of the ground.

The water in the horizontal pipe line is controlled by means of gates placed in large concrete standpipes. In Fig. 1 is shown a section of pipe line with the sides of the standpipes broken away to show the method of controlling the water. In the

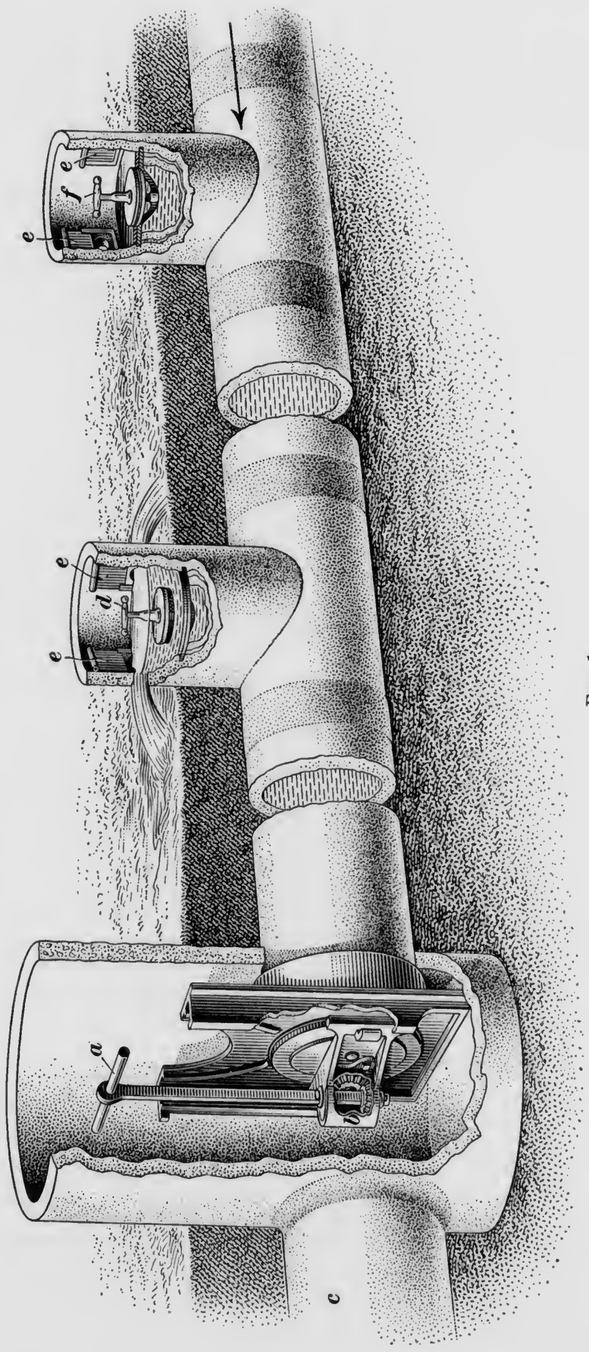

FIG. 1

large standpipe shown at the left is a gate for controlling the flow between two sections of the pipe line. These large standpipes are known as gate stands. The handle *a* operates the gear *b* to control the flow through section *c*. In Fig. 2 is shown a cross-section of a gate valve; *a* is the stem that turns the bevel gears *b* and *c*; the gear *c* has threads *d* that operate the screw *e*. When the valve is opened the head *f* is pulled away from the stationary part *g* and water flows past the opening *h* and a corresponding opening at the top of the head.

The large standpipe at the left of Fig. 1 is also used to carry water over an elevation. In that case the section *c* is connected to the standpipe near the top and the water is allowed to rise to the necessary level to flow out through *c*. The standpipes shown at the right of Fig. 1 are for the purpose of distributing water to the soil and are placed at intervals along the pipe line. Usually there is one of these distributing standpipes at the end of each row of trees. In the middle standpipe, *d* is a valve that, when open, allows water to flow out through openings in the standpipe. The water leaves the standpipe through gates, or jets, *e*, of which there are usually four. In the standpipe at the right, *f* is a valve closed.

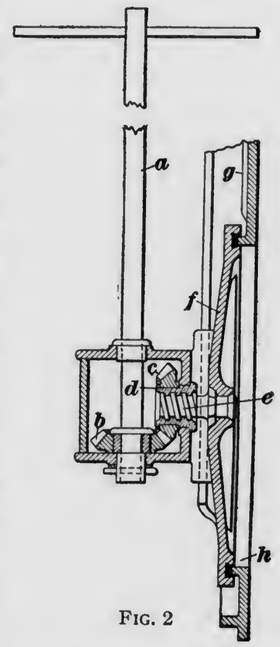

FIG. 2

A view of an orange grove at Pomona, California, is shown in Fig. 3. This illustration was made from a photograph furnished by the United States Department of Agriculture, and shows the water coming from the gates, or jets, of the distributing standpipes at the ends of the rows of trees. The water is flowing into furrows that pass down between the rows of trees. A discussion of the methods employed for conducting the water through the grove is given in later paragraphs.

2. When open distributing stands, such as those just described, are used, gate stands are necessary for every 2 feet

of rise or fall along the line. In some groves closed distributing stands such as shown in Fig. 4 are used, in which case not so many gate stands are necessary. The closed tops prevent the water from overflowing, and the water can be carried over swells 5 or 6 feet high. The photograph from which Fig. 4 was made

FIG. 3

is of a young California lemon grove taken shortly after the freeze of 1912-13. Note how the trees were killed back and how new foliage is forming along the upper part of the trunk. The closed standpipe has no controlling valve like that shown in the open standpipes at the right of Fig. 1, but large standpipes with gate valves such as that shown at the left of Fig. 1

occur at intervals along the line. The flow of water from the closed stands is controlled by the use of Campbell gates, or jets, one of which is shown in Fig. 5. These are of galvanized metal and are set in the standpipe flush with the outside wall. Fig. 4 gives a good idea of the way the gates are placed in the

FIG. 4

standpipe. The size of the opening can be regulated by sliding the flat metal piece up or down. The gate shown in Fig. 5 is the largest size. The water passes through an oval opening $1\frac{3}{4}$ inches through its longest diameter and 1 inch in width. The other dimensions are shown in the illustration. Campbell

gates come also in 1-inch and $1\frac{1}{2}$-inch length of openings. The gates sell for from $12\frac{1}{2}$ to $17\frac{1}{2}$ cents, according to size.

3. Groves are divided into sections, and head lines of concrete pipe with stands are run across the orchard from 200 to 800 feet apart. The distance between these rows of stands is known as a **run.** The length of a run is governed by the size of the orchard, the kind of soil, and the grade between runs. When the soil is open and water sinks readily through it, runs of from 200 to 400 feet should be used. If longer runs are used in such soils much water is lost in deep percolation on the upper part of the tract. For heavier soils with a slight grade, runs of from 400 to 500 feet are used, while if the grade is steep the runs may be from 600 to 800 feet in length. The grade between runs varies from about 1 per cent. to 15 per cent. The average is about 3 or 4 per cent. On a steep grade the soil is washed more than on slight grade, and consequently a smaller stream of water is used for irrigating.

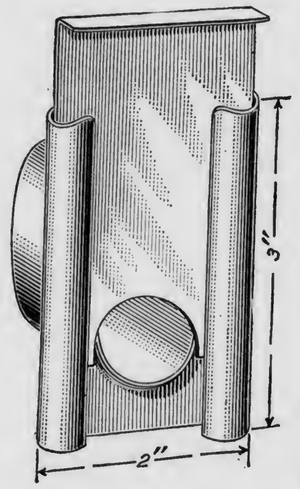

FIG. 5

4. There are three different methods of supplying water to the trees: (1) *Furrow irrigation,* (2) *basin irrigation,* and (3) *overhead irrigation.* Furrow irrigation is usually employed on soils of the heavier kinds, such as clays, adobes, and loams. Basin irrigation is the method usually employed for sandy or gravelly soils. Overhead irrigation can be used on any type of soil.

5. Furrow Irrigation.—In a large proportion of the groves in the West the water is distributed in furrows. These furrows may be approximately straight and parallel throughout the length of the run, some may zigzag throughout the distance to be irrigated, or some may wind in and out among the trees. These different methods of furrowing a grove are known as the *straight-furrow method,* the *zigzag-furrow method,* and the *winding-furrow method.*

6. In the straight-furrow method, several approximately straight furrows are run between the tree rows and the water from the standpipes is allowed to flow into these furrows. Fig. 6 shows approximately straight furrows between two rows of


FIG. 6

mature orange trees, and Fig. 7 shows furrows running the whole length of the grove.

In Fig. 8 (*a*) is shown a diagram of the straight-furrow method for young trees; *a* is the head furrow from which the

water passes to the furrow *c* between the tree rows; the crosses *b* are young trees. Following the planting, as soon as the ground is sufficiently dry to avoid being baked by the heat of the sun, a furrow *c* is plowed with a right-hand 12-inch moldboard plow

FIG. 7

along each side of the tree row and water is allowed to flow into this furrow whenever irrigation is necessary. One furrow on each side of a row is all that is generally necessary up to the second year after the trees are planted, but as they grow older

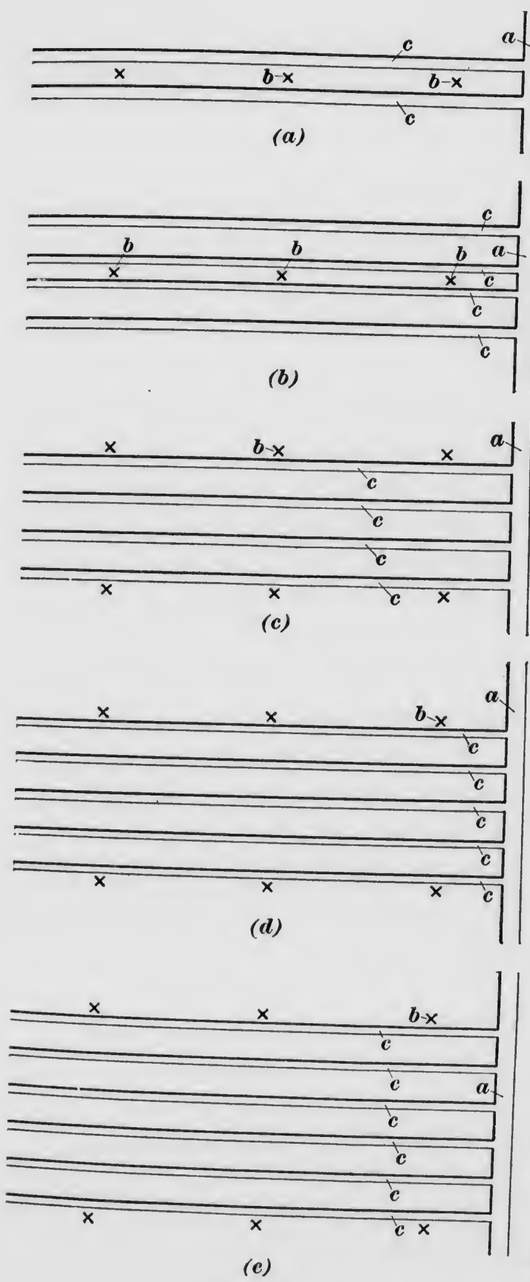

FIG. 8

and more water is required, more furrows are used. In the second or the third year, and in some cases longer, a second furrow is made on each side, as shown in (*b*). After the fifth or the sixth year, two more furrows may be made between each two rows, making four in all, as shown in (*c*). However, many growers claim that there is a better distribution of water by making five or six furrows, as shown in (*d*) and (*e*).

7. The stirring plow is the implement generally used for making one, two, or five furrows. The cultivator shown in Fig. 9, with the teeth removed and shovels known as furrow openers attached, is used for making four or six furrows. Either two or three shovels may be attached. When four furrows are required two shovels are at-

tached and the four furrows are made by one trip down the row and another back, the trip in each direction covering half the width of the strip to be furrowed. When six furrows are to be made three shovels are attached to the cultivator and the trip up and down the rows made.

Hand shovels are used to make the connecting head furrows from the standpipes to the furrows between the trees. These connecting furrows are shown in Fig. 3.

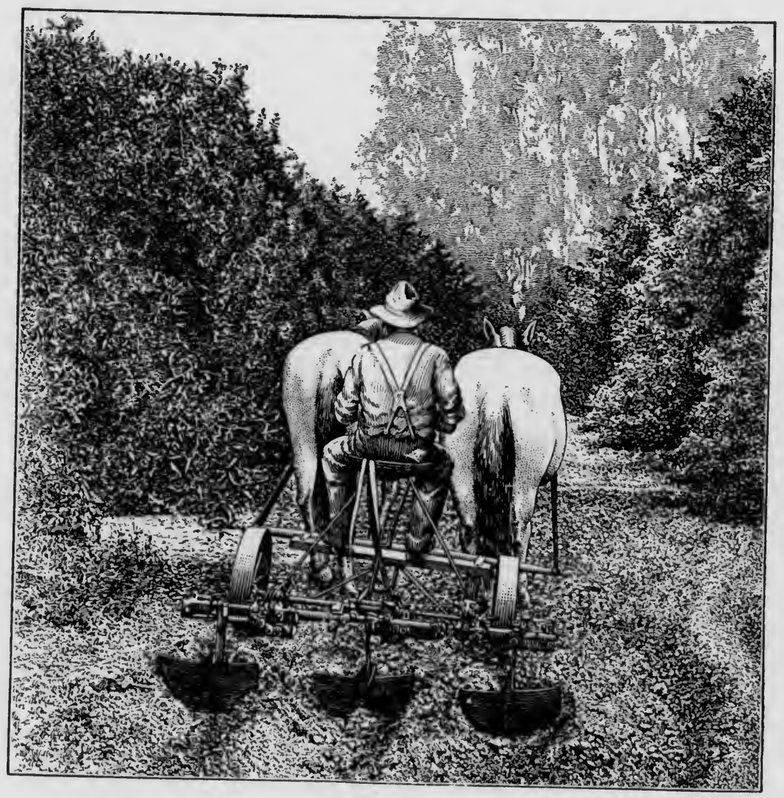

FIG. 9

8. The straight-furrow method is the one generally used when the trees are small. When they get large, it becomes difficult to get near the trees in making the furrows, and the zigzag-furrow or the winding-furrow method is then used by many growers. Some prefer, however, to use the straight-furrow method, even in mature groves.

A grove at Pomona, California, watered by the zigzag-furrow method is shown in Fig. 10. The photograph from which this illustration was made was furnished by the United States Department of Agriculture, and gives a good idea of the appearance of a grove being irrigated by this method.

Fig. 11 is a diagram of a grove watered by the zigzag-furrow method. The head furrow *a* is shown at the right, and the

FIG. 10

trees are designated by crosses *b*; the dotted lines *c* represent cross-furrows parallel with *a* and are made before the main furrows *d*. The short, zigzag furrows are then formed by banking the cross-furrows and main furrows and making connecting furrows *e* as shown by heavy lines in the illustration. The implement shown in Fig. 9 is used for making both the cross-furrows *c* and the main furrows *d*.

9. Other forms of zigzag furrows are shown in Figs. 12, 13, and 14. In each of these illustrations *a* is the head-furrow, the crosses *b* are the rows of trees, *c* the cross-furrows, and *d* the main irrigating furrows. The furrows are made the same way as those shown in Fig. 11, but the short furrows *e* in Figs. 12 and 13 are made by hand. It will be seen that more hand labor is required for both of these systems than for those illustrated in Figs. 11 and 14.

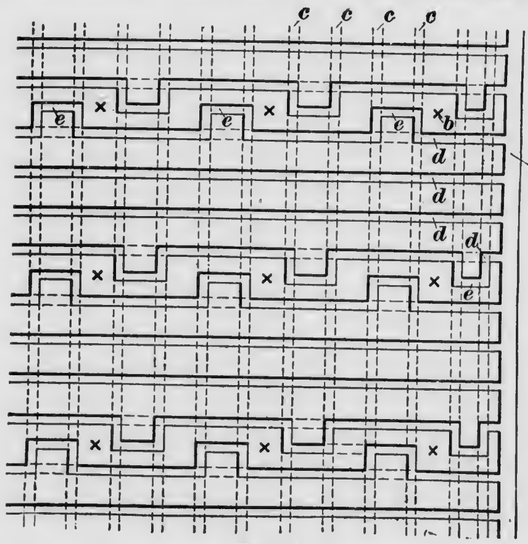

FIG. 11

10. Diagrams of groves watered by the winding-furrow method are shown in Figs. 15 and 16. In both illustrations, *a* is the head-furrow and the crosses *b* the rows of trees. In Fig. 15, *c* is a winding furrow made from one side of the tree to the opposite side of the next, and is made before the main furrows *d*. An advantage of this method is that no hand work is necessary. In Fig. 16 there are two winding furrows *c* and *d*; *e*, *e* are short connecting furrows about 4 feet apart and are made by hand; the main furrows are shown at *f*.

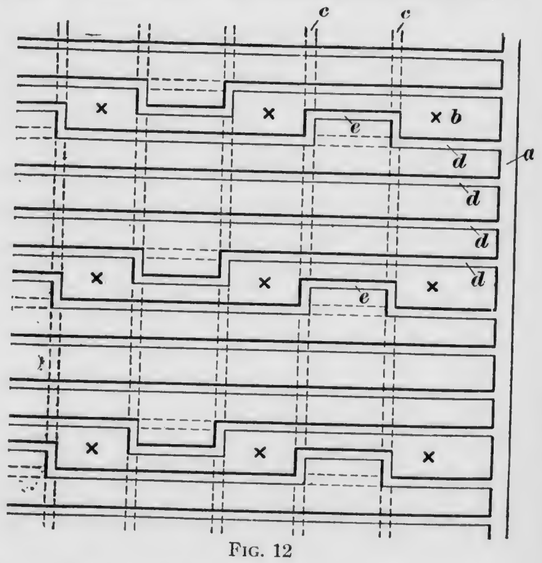

FIG. 12

11. The procedure in irrigating by the furrow method is about as follows: The irrigator walks along the line of standpipes and opens all the jets, one into each furrow. He then proceeds to the other end of the furrows and notes the flow of water through them. If the water does not reach the ends of all the furrows at nearly the same time, he notes on paper the numbers of the furrows in which the water has not reached the end, and then returns to the head end and cuts down the flow in the furrows in which the water has reached the end and increases the flow in the others. This procedure is repeated until just enough water is admitted to each furrow so that it will run through, but none will be wasted at the end. Gopher and mole holes should then be looked for, and if any are found they should be stopped up. Watch should also be kept for accumulations of leaves, which may dam up the water and cause it to break over from one furrow to another, thus causing serious trouble. After the flow of water has been well regulated, not

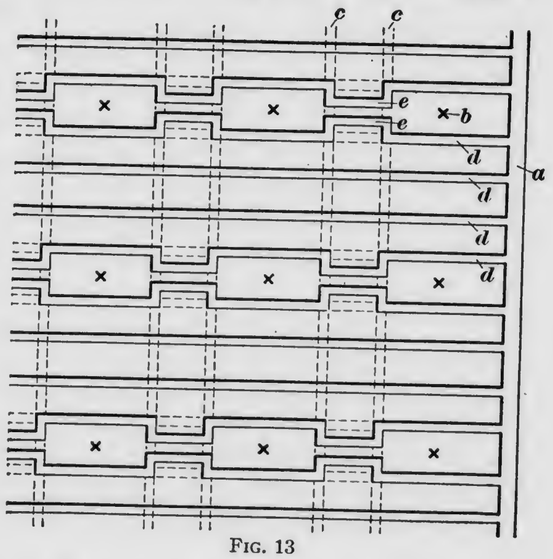

FIG. 13

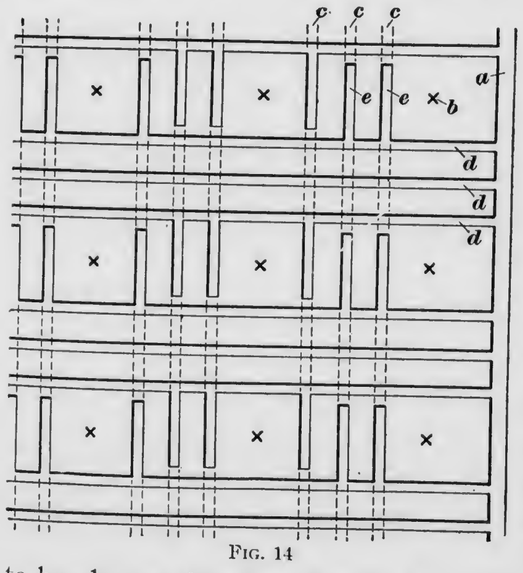

FIG. 14

much attention is required, although a constant watch should be kept for breaks in the furrows. As the flow of water is kept up day and night until the grove is irrigated, about half the work is done at night, and there is a constant temptation for a workman to take a nap. This should not be permitted, as a break may occur at any time.

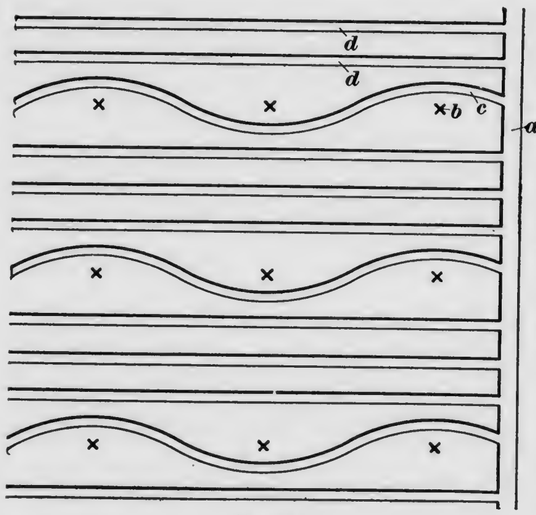

FIG. 15

12. In all systems of furrow irrigation, the water in the furrows should run slowly, for if it runs rapidly excessive washing of the surface soil is sure to occur. The furrows should be at least 6 inches deep. Water percolates more deeply into the soil in deep furrows, and there is less drying out than in shallow furrows. Exhaustive experiments performed by the California Experiment Station, reported in a United States Department of Agriculture bulletin, prove that deep furrows are much to be preferred to shallow ones for citrus-grove irrigation. The soil should be as nearly of the same wetness at both ends of the furrow as it is possible to get it, because

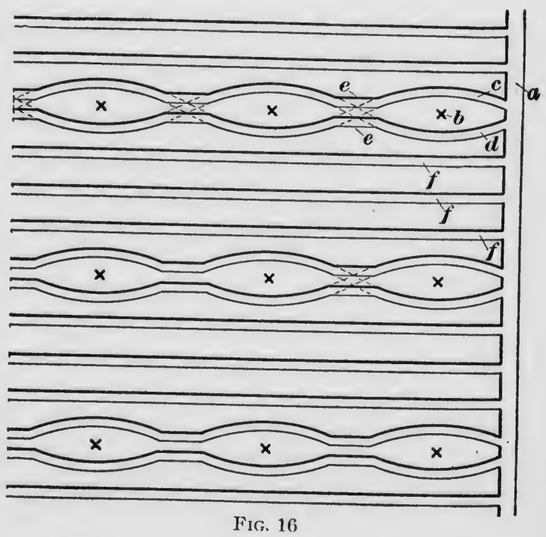

FIG. 16

an excessive quantity of water at any point is detrimental. Too often an excessive quantity collects at the ends of the furrows and in such instance the trees show the effects of improper treatment; they are stunted, sickly, and yellow of leaf. Too much water is as bad as too little, as it crowds out the air and packs the soil. A tree cannot be expected to live in a water-logged soil.

13. Basin Irrigation.—In some cases groves are irrigated by forming basins about the trees. To form the basins, ridges of earth are thrown up midway between the trees in two directions at right angles to each other. This divides the area into squares, with a tree in the center of each, as illustrated diagrammatically in Fig. 17. This figure is explained in detail in Art. **15.** A view of a grove irrigated by the basin system is shown in Fig. 18, which was made from a photograph furnished by the United States Department of Agriculture. The ridges are made with an implement known as a *ridger*, a common type of which is shown in Fig. 19. This implement, which can be made on the farm, consists of two runners *a* 18 inches high, 2 inches thick, and 8 feet long. They are shod with sheet steel *b*, which extends over the bottom and up the inner side. These runners are 5 feet apart at the front end of the implement and 2 feet apart at the back end. Near the front end they are held in place by a 6-inch crosspiece *c* bolted through a strap iron *d* and angle braces *e*; near the back end they are fastened by means of bolts that pass through a strap iron *f*, angle braces *g*, and the top boards *h* of the implement. The hitch is made to irons *i* on the front of the runners. The ridger,

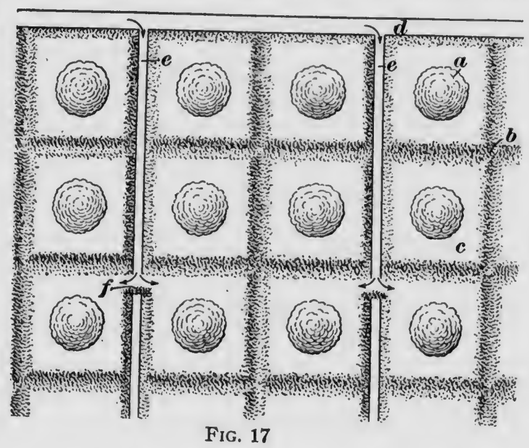

FIG. 17

when pulled through soft ground, throws up a ridge of earth, as shown in Fig. 20, which shows a ridger of slightly different construction than that shown in Fig. 19. If the ground is hard, a plow is run through it before the ridger is used. The water in the basin during irrigation will be from 4 to 9 inches deep, depending on conditions, and the ridge should be several inches

FIG. 18

above the level of the water. A double ridge is necessary to make the furrows to convey the water to the basins.

14. In making the cross-ridges to complete the basin around a tree, a break is made at the intersection of the ridges, and this must be closed up before the water is turned into the furrows. What is known as a *jump scraper*, or horse shovel, is used for this purpose. This implement, which is illustrated

in Fig. 21, can be made by a local blacksmith. The beams *a* are made of $1'' \times 1\frac{1}{4}''$ iron and are 30 inches long from the hook *b* to the downward bend at the rear. The beam extends down the back of the shovel *c* so as to make the bottom edge extend 6 inches in advance of the top edge. The shovel is made of No. 16 sheet iron and is 18 inches wide and 24 inches long. The braces *d* are of $\frac{3}{8}$-inch round iron. The handles *e* are a pair from a discarded cultivator.

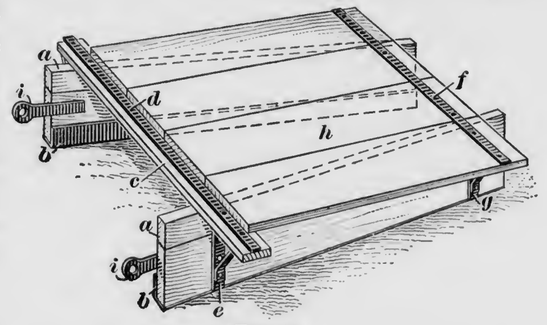

FIG. 19

15. Fig. 17 illustrates a practical method of irrigating a citrus grove by the basin method. In the figure, *a* represents the trees, *b* the ridges, *c* the basins, and *d* the water supply at the edge of the grove. The wide furrows *e* are run from the head-furrow between every two rows of trees to the lower basins of the area, and the ridges are opened in pairs as shown at *f*. After the lower pairs have been watered, the openings are closed, and the next pair above are opened and watered, and this is continued until all the basins have been irrigated. In Fig. 18, two basins are opened on the same side of the irrigating furrow instead of on opposite sides as shown in Fig. 17.

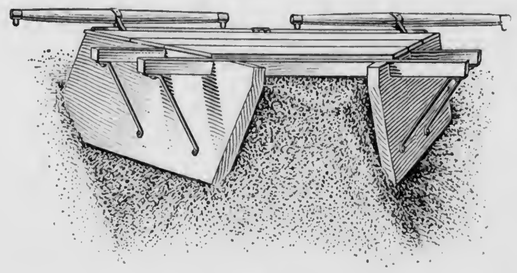

FIG. 20

16. Basin irrigation is used more often on sandy or gravelly soils than on other kinds. The furrow between the basins is wide so that the water can be allowed to flow in large volume to the lower basins. Since the lower basins are irrigated first, the upper basins receive no more water than the lower, except

what is gained by percolation through the soil, from the head-furrow. In furrow irrigation the flow of water is much slower, in order that the soil may be uniformly moistened throughout the entire length of the furrow. This necessitates a smaller

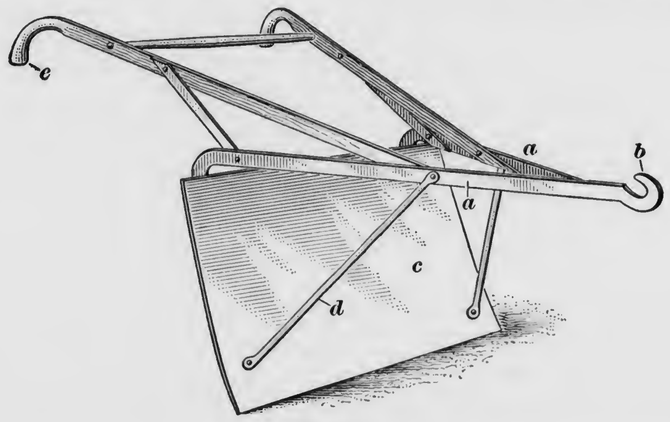

FIG. 21

flow of water, which, in the case of furrow irrigation on loose or gravelly soils, would be nearly all absorbed by the soil near the head-furrow and would percolate to depths below the tree roots by the time the soil at the lower end of the area has received sufficient water. Fig. 22 illustrates in diagram a hypothetical section of sandy or gravelly soil along an irriga-

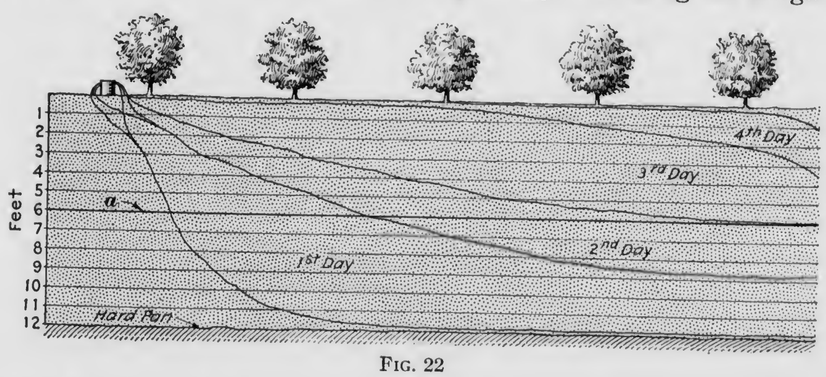

FIG. 22

ting furrow and shows how the water will be wasted if furrow irrigation is practiced. This soil is supposed to be underlaid at a distance of 12 feet with hardpan. In practice, the soil should be wet to a depth of about 6 feet. All water that soaks

below this depth is of no benefit to the trees. In the figure, the 6-foot depth is marked *a*. Suppose water is turned into the furrow from the standpipe shown at the top of the section. Obviously, if the soil is sandy or gravelly, water will percolate rapidly and much of it will get below the line *a*. The lines from the standpipe at the top and left of the illustration show about the portion of the soil that will be moistened on the first, second,

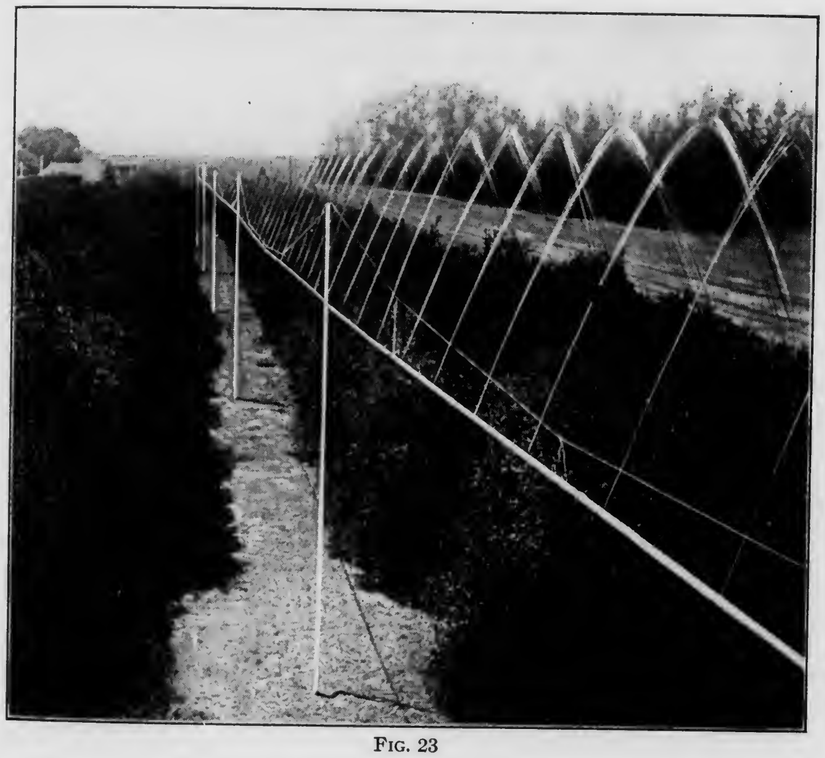

FIG. 23

third, and fourth days. When the water reaches the hardpan it will stop percolating and run off latterly.

17. Overhead Irrigation.—The Skinner system of overhead irrigation has been installed in some citrus groves in California. This system consists essentially of parallel lines of elevated pipe in which are inserted at intervals specially devised nozzles from which the water passes in a fine spray, as illustrated in Fig. 23.

In the grove shown in Fig. 23, the water is from a well 147 feet deep, and it is raised by a deep-well pump run by a 40-horse-power gas engine. A centrifugal pump keeps the pressure on the line at about 40 pounds to the square inch. The supply pipes run down the center of the orchard, and from them branch off the delivery pipes, one over every other row space between the trees. These pipes are at an elevation of 16 feet above the ground. The nozzles are 4 feet apart, and the streams of water are thrown laterally about 15 feet. The delivery pipes can be rotated so that they will throw the water in the opposite direction. This is done by means of a turning machine in the pump house. Thus, an area 30 feet wide can be watered from each line of pipe. In this grove the equivalent of 1 inch of rain is applied to the ground in about 12 hours.

The manufacturers of the appliances for the Skinner system of irrigation have for sale all equipment needed for the installation of a complete outfit for a grove of any size, and they should be consulted by those interested in this method of irrigation. The installation of equipment in any particular grove is a problem that the grower and manufacturers should work out together.

18. Quantity of Moisture for Grove.—It is very important that the leaves of citrus trees do not curl for want of water; if they do, it will take months to repair the damage. The needs of the trees should, therefore, be anticipated and damage due to the want of water prevented. The percentage of moisture in the soil should never get below 3 to 4 per cent.; the percentage can be determined by obtaining samples of soil with a shovel or a King soil sampler and testing them for moisture content. The samples should be taken from several places in the grove and from a depth up to 4 or 5 feet.

The King soil sampler illustrated in Fig. 24 consists of a graduated 5-foot brass tube with a cutting head of steel *a*. Graduations are marked on the tube every 6 inches. This tube is pounded into the soil to whatever depth desired up to 5 feet. In the illustration it is shown to be nearly 3 feet in the soil. A steel collar *b* is at the top of the tube to receive blows of a

hammer *c*. This hammer, which is of cast iron and weighs 8 pounds, is fastened to a tube that fits down into the collar *b* and the tube. The tube is driven into the ground by raising the hammer and forcing it down against the collar. A column of soil is thus forced into the tube, and when the tube is withdrawn the column of soil comes with it. The soil can be removed easily and is the sample to be tested for moisture. The parts lettered *d*, *e*, and *f* are the tube hoist; *d* is the frame, *e* is a circular piece of metal that rests on the surface of the ground, and *f* is a pair of handles. By pulling upwards on these handles the tube of soil is pulled from the ground. The sampler can be had without the tube hoist if desired, and in many soils it is possible to obtain the samples without the use of the lifting device.

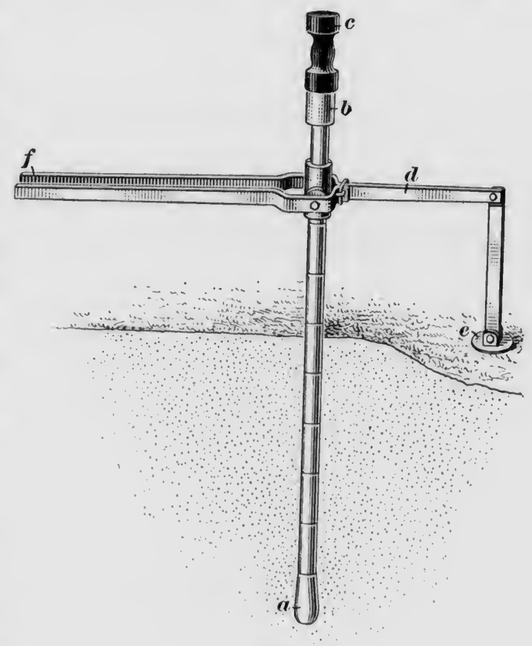

FIG. 24

19. All the apparatus required to make the moisture determination of a sample of soil is a pair of small, fairly accurate balances. The work can be done in the grove with a sufficient degree of accuracy on a hot sunny day. A piece of glass is placed on one of the pans, the scales balanced, and a sample of soil weighing a pound or two spread out on the glass and left in the hot sun to dry for the better part of the day. The weight of the soil is again determined and the percentage lost computed on the basis of the weight of the dry soil. The percentage of moisture lost is capillary moisture. There still remains in the soil a certain percentage of hygroscopic moisture that can be

removed only by means of a high temperature. It is not necessary, however, for the grower to know the percentage of hygroscopic moisture in soil, for it is the capillary moisture that plants use.

Frequently it is desirable to weigh the soil samples in the house or in some shed and thus avoid carrying the balances to the field. As a protection against the drying of the soil samples by the sun while they are being transferred from one place to another, they are placed in small tin dishes with air-tight covers. In case it is desired to make a moisture determination on a foggy day, the sample should be brought into the house, weighed, spread on the glass, placed in a moderately hot oven for 2 or 3 hours, weighed again, and the percentage of moisture computed. The heat of the oven must not be too great, as it will oxidize some of the humus and drive off a certain amount of hygroscopic moisture, and, as a result, the percentage computed will not be the percentage of capillary moisture and the results will not be in accord with field conditions.

Some growers are likely to feel that the making of moisture determinations as here outlined are unnecessary and somewhat out of their line. There are, however, growers in the West who have gotten into the habit of doing such work and find it no more troublesome than any other farm operation.

After a grower has had some experience in examining soil for moisture, he will learn to tell by its feeling and appearance whether it is in need of irrigation or not. A grower should exercise extreme care that at all times there is sufficient moisture for the needs of the grove.

After an irrigation, the soil should be moist to a depth of 5 or 6 feet. In a loam soil, the top 5 feet should show 12 per cent. moisture. In sand, the moisture may be slightly less and in adobe slightly more, say, a difference of 1 or 2 per cent. in both cases. In many soils, due to a plow sole, it is difficult to get the water to penetrate below 18 inches. Under such conditions a subsoil plow run once down each middle and once down each cross row, regardless of roots broken, is good practice. Water must be gotten down to a depth of 5 or 6 feet or the grove will certainly decline.

20. Frequency of Irrigation.—It is impossible to specify how often a citrus grove should be irrigated during a season, as all soils are not the same in water-holding capacity; also, growers who own stock in water systems must take their turns in securing water. Usually this is arranged for every 30 days. A grower can generally order a few more or a few less inches than the usual quantity. If a grower gets his irrigating water from a well he has more choice in the matter, and, naturally, can apply the water more in accordance with the soil needs than can the man getting water from a company. However, this does not mean that the man getting water from a company should not test his soil for moisture. If the tests show that he has not been getting enough water in the past and if he cannot arrange to get more water from the company, he should drill a well or devise some other means of getting an additional supply.

PRUNING ORANGE TREES

21. The idea once prevalent that orange trees do not require pruning is rapidly disappearing. The experience of growers in their efforts to rejuvenate old trees that have never been pruned, or to train young trees that have been allowed to shape themselves, has been convincing evidence in favor of careful pruning of all citrus trees. As with deciduous trees, proper training of citrus trees during the first few seasons of their growth will make future pruning less difficult and expensive. After orange trees have become well established and are bearing, heavy pruning is seldom necessary, but, nevertheless, a certain amount of systematic annual pruning is advisable.

22. Pruning Young Trees.—The first pruning a young orange tree receives is in the nursery when the head is formed. Young trees are headed from 28 to 36 inches, usually about 33 inches. Trees headed thus are, when mature, of a height that permits of tillage implements being used close to the trees.

One of the most important requirements for a young tree is the proper spacing of the four or five main branches that are to be the framework of the mature tree. These branches should

be as well distributed around the trunk as possible and in a vertical direction should be spaced preferably about 6 inches apart. When the nursery trees are ready to be set in the grove, the main branches should be cut back to over half their length, preferably to a secondary branch growing outward; in case no branch is thus situated, the cut should be made just above an outside bud. After the tree is planted in the orchard, no heading back of the main branches need be practiced for the first 2 or 3 years. The suckers that appear on the upper part of the trunk should be rubbed off; sprouts that start on the main limbs and grow toward the center should also be removed. Some of the more vigorous shoots from near the center may be left. Such treatment during the early period of the tree's life in the grove allows the root system to get well established and has a tendency to form an open tree that will bear fruit on the inside. If the growth on the main branches is headed back early, numerous smaller branches start out and fill the tree with brush and a mass of foliage. By heading in the main leaders later, the strong upright growth continues and buds lower down push out fruit wood.

The mistaken idea that the branches of the Bahia orange tree naturally tend to grow downwards arises from the fact that the branches are pulled down by their own weight. If sagging branches are cut back to an upper bud, the resulting growth will tend upwards; branches more nearly vertical may be cut back to a bud, which will spread the growth outwards. Although some growers may contend that it is better to let the lower branches come to the ground, even if considerable fruit rests on it, the tendency at the present time to is keep the hanging branches pruned away, as the fruit produced on such branches usually grades into more culls than does the fruit produced higher up and closer to the main branches.

23. Pruning Old Trees.—Any one who has had experience with unpruned bearing trees realizes the great difficulty of getting into the inside of such trees and removing the dead wood and weaker branches. Such trees may be producing fair crops and a good quality of fruit, but in most cases they are

undoubtedly falling far short of their maximum capabilities. Many of the central branches and outer twigs have died, not because they have fulfilled their mission but because they were crowded so close together that they did not have room for development, and a large number of them have never had the opportunity to become useful. If light and air is admitted into the interior by judiciously thinning out the central branches, the results will soon justify the expense. The pruning out of some of the central branches to admit light to the interior part of the tree is known as the *open-center* method of pruning. In this method, the light is not admitted in one large opening, such as is sometimes made in topping, but the foliage is thinned out to admit light in small openings all around the tree. The main limbs will then send out an abundant growth of good fruit wood, and the result will be a crop of fine oranges on the interior as well as on the outer branches of the tree. Suckers that appear should be removed. They may generally be distinguished from the fruit wood by their more angular stems, the presence of thorns, and larger leaves, and the tendency to grow toward the top of the tree in a direct line and as rapidly as possible. If sucker growth continues, it dominates the tree and changes it to a wood-forming, or timber, tree, instead of a desirable fruit-bearing tree.

The advantages of the open-center method of pruning are that the results are more lasting and the annual pruning required later is less expensive. Easy access is also gained to the center of the tree for performing necessary pruning and harvesting operations.

The fact that fruit on young trees is more firm on an average and of better quality than that on old trees, leads some growers to endeavor to prune in such a manner as to renew the whole top of each tree about every 7 years. This is done gradually by taking out a good-sized branch each year. This gradual renewing of the top is to be commended, as results justify the practice. It is a good plan, also, to prune each main branch separately and systematically, taking into account, of course, its relation to the tree as a whole. Pruning on the outer branches should be light. If any cutting on outer branches

needs to be done at all, it is usually better to cut the branch off entirely where it unites with the mother limb; if the branch is lopped off part way down, a dense growth of brush results and more pruning will be necessary later.

24. Varietal Differences in Pruning.—The Washington Navel orange tree that has been grown from buds gathered promiscuously, has a tendency to send out vigorous, upright branches, which, if they are allowed to remain, rob the sap from near-by branches and develop so rapidly that they soon overtop the rest of the tree and form what is commonly known as the Australian type of navel. The Washington Navel orange tree grown from a bud selected from a good standard tree has very little of this tendency. Such growth should be vigorously suppressed. It may be discouraged by proper open-center pruning.

25. Season for Pruning.—Orange-tree pruning should follow the removal of the crop. The tree should be brought into good condition by blossoming time and then left severely alone until the fruit sets, with the exception that sprouts on the trunk, and stray branches should be removed whenever found.

26. Root Pruning.—Root pruning, as such, is never advisable for citrus trees. Roots are often cut or torn out during the process of subsoiling or of breaking up plow sole; such injury, however, is seldom serious enough to warrant the discontinuance of such operations, if the deep plowing is done only along the middle of the rows.

27. Pruning Frosted Trees.—The pruning of frosted trees should be deferred until it is plain just how far back the wood has been killed. Young trees that have been only partly frozen usually show more injury in the rapidly growing upright shoots than in the fine fruiting wood. Such injured shoots had better be removed entirely, as a simple cutting back will result in a dense brush-like growth.

Badly frozen trees are out of balance. The uninjured roots continue to supply moisture and plant-food to the top, with the result that a very dense growth of new shoots appears all over the trunk and branches. Where sufficient labor is available, such growth may be thinned out, leaving the strongest fruiting wood to renew the top. In case of a shortage of labor,

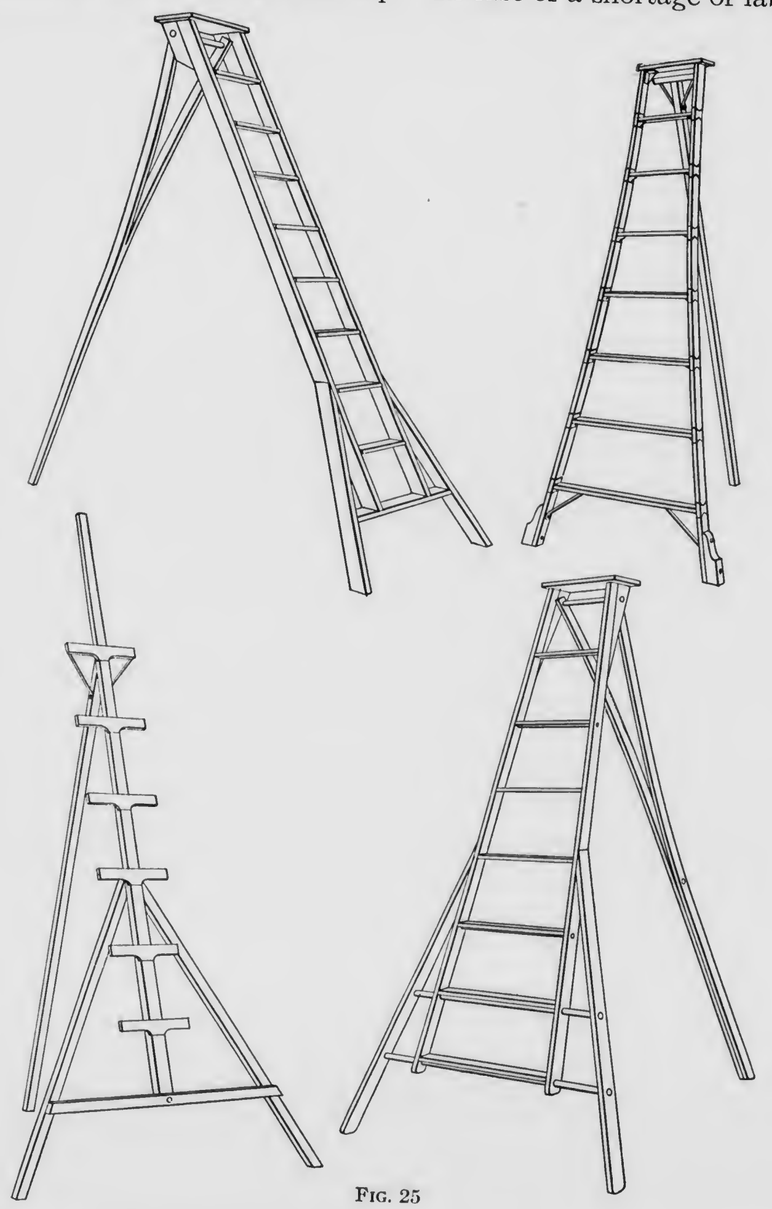

FIG. 25

the thinning may be done by removing entirely a certain number of branches.

28. Pruning Outfit.—A pruning outfit consists of a light ladder, a pruning knife, hand shears, long-handled shears, saws, gloves, a brush, and a supply of wound dressing.

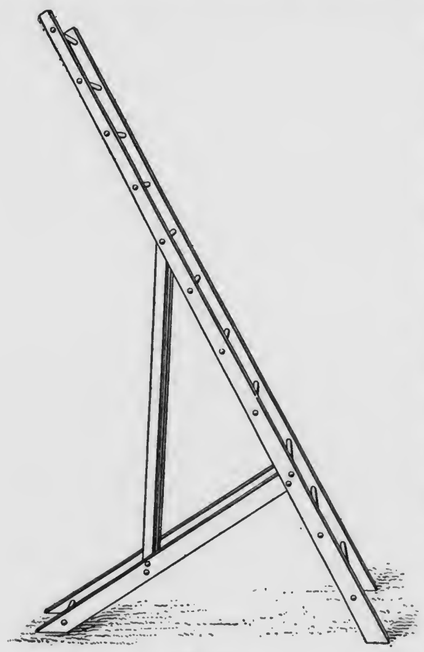

FIG. 26

Three-legged fruit ladders, several styles of which are shown in Fig. 25, are convenient for pruning work. By raising the third leg and dropping it through the foliage to the ground under the branches, the top of the ladder is brought near the top of the tree without injuring the small outer branches. Another good style of ladder is shown in Fig. 26. An advantage of this ladder is that the operator can get to the branches of the tree without pushing the ladder through the foliage.

A strong pruning knife may be used efficiently on young trees. For work on older trees, a pair of hand shears is necessary for removing small branches close at hand. The type with one blade and a guard like the pair shown in Fig. 27, is more satisfactory than those with two cutting edges, because they will make a smoother cut. When shears with two cutting edges are used, both

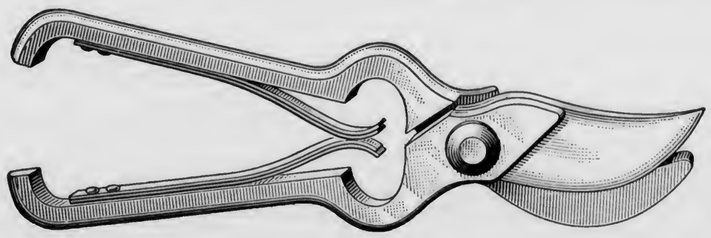

FIG. 27

edges cut into the limb and leave a ragged edge at the center where they meet, but with only one cutting edge,

this difficulty is obviated. Long-handled shears are used to remove branches not easily reached from the ground or the ladder. They are especially useful for pruning the interior branches of the tree. In Fig. 28 is shown the Malaga shears, a style much used in California.

A saw is necessary for removing large branches. In Fig. 29

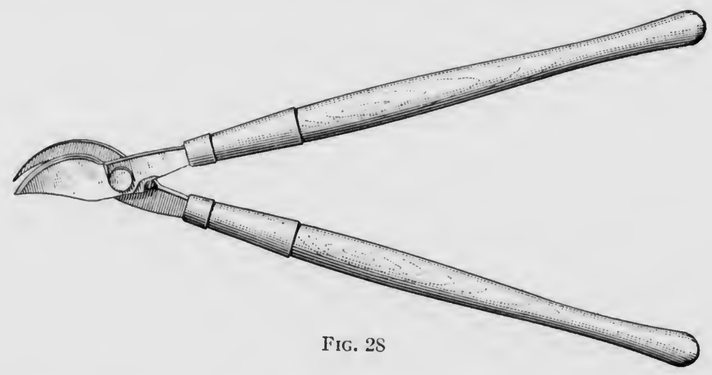

FIG. 28

is shown an inexpensive saw much used in California. It is fitted with a swivel blade, which makes it possible to have the frame at a different angle from the blade when sawing, which is often an advantage. The point of the saw is narrow and enables the pruner to remove limbs that are close to others.

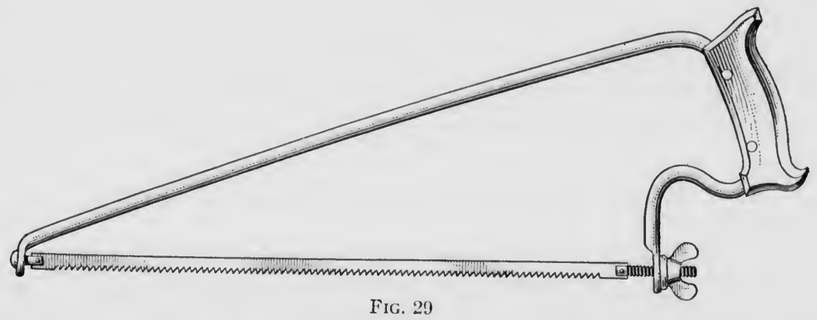

FIG. 29

Many types of saws are on the market and the grower has no difficulty in choosing the type that suits his fancy. A type to avoid, however, is one with teeth on both edges, as wounds and cuts in the bark of near-by limbs are sure to be made with such an implement.

29. Disposition of Prunings.—The practice of burning the branches removed from citrus trees should be discouraged except in groves where fungous diseases of the trees occur. In healthy groves the prunings had better be cut into pieces and cultivated into the soil where they will decay and add humus. While the prunings lie on the ground, boys may be employed to cut them into pieces with long-handled shears. In large orchards, brush cutters run by gas engines are often employed. In one large California orchard, a trench is dug between each two trees in a row; this trench is then filled with the prunings, manure and available refuse and covered over with the soil which was removed.

30. Precautions in Pruning.—The pruning tools should be sharp in order that clean wounds can be made. The wound should be parallel to the direction of the branch on which it is located. Branches should be removed as close as possible, without cutting into the surface of the branch from which they spring. Shoulders and stubs should not be allowed to remain. They cannot heal over and as they decay, they afford a place of entrance for rot-producing fungi to the body of the tree, thus shortening the life of the tree and weakening its resistance to winds and storms. In removing branches of considerable size with the saw, the cut should be started on the under side and finished from above; the branch will then fall without splitting or tearing a strip of bark from the wound. Wounds over $\frac{3}{4}$ inch in diameter should be painted or waxed over to prevent decay and checking in growth.

31. Dressings for Wounds.—A good wax for dressing wounds may be prepared by melting together 6 pounds of resin, 1 pound of beeswax, and 1 pint of linseed oil. This preparation hardens when cold and must be kept melted over a fire while being used. It is applied to the wound with a brush. By adding more linseed oil and a little alcohol and turpentine and at the same time decreasing the amount of resin, the wax will not harden and can be used cold. If too much beeswax is used, the mixture may melt in hot weather and run down over the bark.

White lead and other similar paints are often used for covering wounds, but recent experiments in California have demonstrated the superiority of asphaltum paint for this purpose. Its cheapness and ease of application make it practicable, and the indications are that the healing of the tissues takes place more rapidly than when almost any other dressing is used.

COVER CROPS IN GROVES

32. In many localities the soil in citrus groves is deficient in humus, or organic matter. Humus can be supplied by barnyard manure, but this is impractical in large groves, and what is known as cover cropping is resorted to. The cover crop is not harvested but is turned under to improve the physical condition of the soil. By this means heavy soils that are inclined to bake and form a crust at the surface are made more porous and open, and light, sandy soils are made more retentive of moisture. If a legume is used as a cover crop, nitrogen in an available form is added to the soil. This improved physical condition of the soil results in more thrifty trees and in an increased yield and a better quality of fruit. Cover crops also prevent excessive washing of the soil on rough land by the heavy rains of winter.

33. It would seem from the foregoing statements that the use of cover crops would always be advisable in groves in which the soil is deficient in humus and nitrogen. This is not the case. Cover crops consume considerable water, and if water for irrigation is scarce, the trees would suffer through lack of sufficient water to supply their needs. In the citrus districts of Southern California, the climatic conditions are such that cover crops can be used to advantage, and they have been used in those districts longer than in other districts of California and in Arizona. Experiments in the last sections named, however, show that, under some conditions, cover crops can be profitably grown. In groves where the growing of cover crops is not advisable, stable manure is often used to advantage.

34. In most instances, the cover crops are planted in the fall from late August to the first of October, the exact time

depending on the crop sown and on the region where it is planted. The crop should be turned under before the trees start growth in the spring. For Southern California, this means not later than the last of February, and usually it is done about the first of February. In other California districts, the time for plowing under is a little later, on account of the wet condition of the soil. In Arizona, cover crops are plowed under early in April. These fall-planted crops are known as winter cover crops.

Winter cover crops should be able to withstand considerable trampling from teams and pickers without much injury, as the crop is on the ground when the fruit is being harvested.

Some of the best growers in California practice summer cover cropping. Where there is an abundance of water, this may be a wise practice if the soil is much in need of humus and the owner desires to build it up rapidly. In most cases, however, especially in old groves, the practice is somewhat questionable, because, as the summer season is dry, the cover-crop plants are likely to use water that is needed for the trees.

35. Plants suitable for winter cover crops in California are common, or spring, vetch, barley and vetch together, Canada field peas, bur clover, and fenugreek. Plants suitable for summer cover crops are cowpeas and buckwheat.

In Arizona, cover crops are planted only in the fall. *Melilotus indica*, known locally as sour clover, is the principal plant recommended as a cover crop in this section. Yellow sweet clover and bitter melilot are common names for the plant elsewhere. Alfalfa is also sometimes used as a cover crop in citrus groves in Arizona.

When determining on the kind of cover crop to plant, the locality, the soil, and the price of seed should be carefully considered. In general, it may be said that leguminous cover crops give the best results, because available nitrogen is increased in the soil. Often, however, barley, a non-legume, is planted with legumes that have a tendency to lie flat on the ground as the legume can climb on the stiff stems of the barley, and thus be held off from the ground.

36. Common, or spring, vetch is the plant most used for a winter cover crop in the citrus regions of California. It is

FIG. 30

adapted to variable conditions and succeeds well under most climatic and soil conditions. The plant makes a vine-like

growth that is able to withstand trampling without much injury, and the root system is extensive and is usually well

FIG. 31

covered with nodules, thus insuring added nitrogen to the soil. In Fig. 30 is shown a Southern California grove with a luxuriant

cover crop of common vetch. Note the excellent stand of the plants and how completely the ground is covered by the crop.

To secure the best results in Southern California, vetch seed should be planted the latter part of August or the first part of September. When planted early in the season, vetch makes a good growth before cold weather and continues growing during the winter. Plantings in October are sometimes made, but, as a rule, they are not satisfactory on account of the small growth made before cold weather. In the northern sections, common vetch may be sown about October 1. This late planting is possible on account of the heavy winter rainfalls that occur in this section, which does not permit the turning under of the crop as early as in the southern section.

The rate of seeding varies from 40 to 60 pounds per acre. In a grove where the trees are 12 years old or older, from 40 to 50 pounds of seed is required per acre. For younger trees, from 50 to 60 pounds per acre is sown. The seed of common vetch usually varies in cost from $3\frac{1}{2}$ to 5 cents per pound. At the rate of 60 pounds to the acre, the cost for seed is, therefore, from $2.10 to $3 per acre.

When barley is seeded with vetch, the average rate of seeding is 30 pounds of vetch and 30 pounds of barley. A planting of barley and vetch is illustrated in Fig. 31. Note the large quantity of foliage.

37. The Canada field pea was the first crop to be used extensively for winter cropping in citrus groves of the West, and it is still used in many of the groves. Although it has many desirable characteristics, the field pea has others that make it less desirable for citrus groves than the common vetch. The crop is adapted to varied conditions and usually grows under most soil and climatic conditions of the citrus-producing regions of the West. It makes a luxuriant growth during cool weather, and, as the roots extend deep into the soil, the plants are desirable for breaking up plow sole in groves where this trouble occurs. Another favorable characteristic of the field pea is that the crop can be planted late in the fall and will produce a good growth for turning under in the late winter. This

is especially valuable when, for any reason, earlier plantings of other cover crops have not been made. There are several objections to the use of field peas as a cover crop: (1) The vines are succulent and tender, and for this reason will not stand much trampling without injury; (2) on account of the field peas growing so well during cool weather, they are likely to be soft and succulent in winter, and hence are easily injured by frost; (3) as the plants approach maturity the stems near the base become dry, and this makes the turning under of the crop rather difficult; (4) the plants are subject to attacks from plant lice, and often these insects cause considerable damage to a cover crop of peas; (5) near the coast the peas are somewhat subject to mildew, but inland this trouble is not so apparent.

The time of planting in Southern California varies from the middle of September to the last of November, but the best results are obtained when the seed is planted early. In the northern sections, the middle of October is the best time for planting. If planted too early, the plants are likely to be injured by winter frosts. At least 80 pounds of seed per acre should be sown, and unless conditions of growth are very favorable the quantity can well be increased to 90 pounds. The cost of seed per pound is about the same as for common vetch. At the rate of 80 pounds per acre the cost per acre will be from about $2.80 to $4.

38. Bur clover is grown to a limited extent for winter crops in the citrus regions of California. Two varieties, the toothed bur clover, which is the most common, and the spotted bur clover, are seen in California. These plants mat close to the ground, and the stems are small and succulent when young, but, nevertheless, the crop stands considerable trampling without injury. The roots are shallow, but are abundant and usually are well supplied with nodules. The plants do not make an early winter growth, and largely for this reason the use of bur clover as a cover crop will always be limited. The crop is sown at the same time as vetch, early seeding being advisable. The quantity of hulled seed to sow per acre is 20 pounds; it should be planted shallow, as deep-planted seed will not come up until

another year. The seed is usually sold at from 25 to 30 cents a pound. At the rate of 20 pounds per acre the cost of seed for each acre sown is from $5 to $6.

39. Fenugreek is a plant that has come into use only comparatively recently as a winter cover crop in California. In 1902 seed was distributed by the California Experiment Station, and since that time its use has gradually increased. Orange and Ventura counties in California seem well adapted for this crop. It will make fair growth in the interior sections, but there the crop seems more exacting as to time of planting and other cultural conditions. The plants are upright in growth, which makes them easy to turn under; the roots have many nodules, and they extend deep into the soil, like those of the field pea. The crop does not seem to harbor any insect pests, which is an advantage over many other cover crops.

In Southern California, sowing early in September is advised. Near the coast, later plantings may often be made with good results, but earlier plantings are considered to be better. In the northern sections, the first part of October is the time for seeding. The quantity of seed sown per acre is usually 30 pounds, this quantity being sufficient to give a good stand for a cover crop. The cost of seed is 5 to 6 cents per pound. The cost per acre at the rate of seeding advised is therefore $1.50 to $1.80.

40. The Whippoorwill variety of cowpea has been found to be a good legume for summer cover cropping in California citrus groves where summer cover cropping is advisable. The seed is sown in the spring after danger of frost is over, and the plants have possession of the ground between irrigations. If the period between irrigations is 60 days, a large quantity of green manure will be provided. Since a cover crop requires liberal amounts of water for growth, a summer green manure crop should not be planted if there is likely to be a deficiency of water. Cowpeas are sown at the rate of 4 to 5 pecks per acre. The price per bushel varies from $2.50 to $4, depending on the season. This makes the cost of seed per acre from $2.50 to $5.

41. Buckwheat is used by a few growers in California as a summer cover crop. At the Leffingwell Rancho, near Whittier, it has been used and it is claimed to have given good results. The seed is sown in the spring as soon as danger from frost is over. In most seasons, this will be about March. About 80 pounds of seed per acre is the usual rate of seeding. The cost of seed averages about 3½ cents a pound. In case the season is favorable, the plants will mature in 7 or 8 weeks. If the ground is irrigated about every 60 days, which is a practice with many growers who pump their own irrigation water, the plants can mature and be plowed under just before an irrigation. The crop will then reseed itself and a volunteer crop come up and be ready for plowing under at the next irrigation. The manager of the Leffingwell Rancho states that buckwheat has done wonders in getting the soil of their groves, which is a rather heavy adobe, into a better mechanical condition.

42. The Agricultural Experiment Station of Arizona has the following to say about the use of *Melilotus indica*, or yellow sweet clover, and alfalfa as green cover crops for groves:

Yellow sweet-clover (sour clover) grows naturally throughout the Southwest, being commonly considered a weed. In Southern Arizona plants are quite common in grain fields, these being the source of the seed used for sowing in orchards. Seed can be obtained where grain has been threshed, or at grist and rolling mills, the cost being slight.

The seed will germinate only during the cool weather from September to April. The earlier it is sown in the fall, the more growth will be secured for turning under in the spring. If sown the latter part of September or the early part of October, it will ordinarily attain a height of 3 to 6 inches before being checked by the cool weather of December and January. It may be sown as late as December, but will not give as heavy a yield as if sown earlier. About 50 pounds of seed should be sown per acre.

The method of seeding found to be the best is to level the ground well, sow broadcast, furrow with a three-shovel furrower, roll, and irrigate by running the water in the furrows, which should be 2 or 3 feet apart. Irrigating it frequently during the winter will not only increase the yield, but will benefit the orchard.

It should be plowed under when beginning to blossom, which will ordinarily be early in April. At this stage the yield proved to be 15 to 18 tons of green matter or 3 to 4 tons of dry matter per acre. If permitted to grow longer it becomes more woody, does not turn under so well, and decays less rapidly * * *.

The alfalfa may be sown earlier than the clover, as the seed will germinate during warmer weather. It does best if sown in the same manner as described for clover. As it does not grow as rapidly during the winter, it will usually not be ready to plow under as early. Thirty pounds of seed per acre will be sufficient.

43. The land to be seeded to a cover crop is generally plowed or disked after an irrigation and then harrowed until a good surface tilth has been secured. The seed is then either drilled or broadcasted, and is harrowed in. Following the seeding and before the seed germinates, furrows or basins are prepared for irrigation purposes during the time the ground is covered with the crop. With the exception of irrigations when necessary, during the fall and winter, nothing more is done to the cover crop until it is time to turn it under. Moldboard plows are generally employed for this purpose.

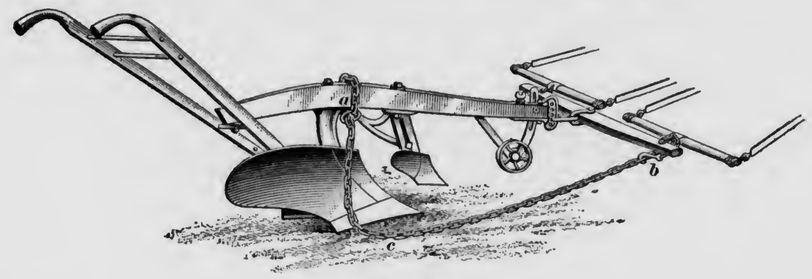

FIG. 32

When turning under standing vegetation for green manure, it is important that all of the plants be completely covered by the furrow slice. There is no better way to get all the growth covered than by the use of a moderately heavy chain attached to the plow. This chain should be looped from the plow beam to the doubletree and allowed to drag on the ground at the side of the plow. The weight of the chain will push all the green material under the furrow slice as it turns over. The chain is placed on the plow by slipping the ring end as a noose around the plow beam, as shown at *a*, Fig. 32, and then looping the hook end around the end attachment of the doubletree on the furrow side of the plow, inserting the hook in one of the links of the chain, as shown at *b*. Just enough slack should be left in the chain so that when the plow is moved the chain will

drag on the ground as shown at *c*. The dragging chain pushes the crop under the furrow slice. The length is readily regulated

FIG. 33

to suit conditions by inserting the hook in different links.

On light soils a disk harrow is often used successfully for working the cover crop into the ground. Four diskings are usually necessary to get the growth turned under, and, obvi-

FIG. 34

ously, each disking after the first one should be made at an angle with the previous one.

Some growers plant the cover crop on only a part of the area between the rows and keep the ground near the trees cultivated. An advantage of this method is that there may be less fungous troubles in the grove, as explained in a subsequent Section. A cover crop of buckwheat and one of vetch, planted in this manner, are shown in Fig. 33 and Fig. 34, respectively. A disadvantage of the method is that less humus and nitrogen are placed in the soil.

FERTILIZING THE GROVES

44. Need of Plant-Food.—Information on the proper quantities and kinds of fertilizer to use for citrus trees is very meager. Most orange growers use fertilizers, yet the information from their experience is very scant and contradictory. It is true that much valuable information regarding fertilizers can be obtained from the most successful orange growers, but what fertilizers may apply to their conditions will not apply for all conditions. Inquiry among orange growers shows that there is little agreement in the practice of applying fertilizers to the trees. In fact, most growers rely mainly on their own judgment. It is, therefore, impossible to give a definite system of fertilizing for oranges adapted to all kinds of soils tilled by all kinds of growers. Only a few most general principles can be given. Some of these, however, are worth consideration.

Fertility can be increased in the soil by the addition of manures, commercial fertilizers, or a combination of both. Manures are two kinds, green manures, which are cover crops that have been plowed under; and stable manures, which may include the manure derived from all animals. The plant-foods applied to the soil in the form of commercial fertilizers are nitrogen, potash, and phosphoric acid. Oranges require many other plant-foods for growth, but they are usually present in the soil in sufficient quantity.

The trees should be very carefully studied before fertilizers are added to the soil, and as far as possible the fertilizer should be adapted to the needs of the trees. When the leaves and twigs of the trees are stunted in growth and the foliage looks

yellow instead of dark glossy green, the indications are that nitrogen is needed in the soil. On the other hand, when the fruits are late in maturing and develop thick, puffy rinds and the tree makes undue wood growth, it is a sure sign that there is excessive nitrogen in the soil and further applications are not necessary.

Lack of phosphoric acid in the soil is indicated by the fruits not developing properly and being tardy in maturing. Citrus fruits grown on soils deficient in potash have thick skins, the same as if nitrogen is too plentiful. The proper supply of potash seems to have a beneficial effect on the keeping quality of the fruit.

If these conditions are kept in mind and the trees carefully watched, a grower can usually keep the soil in good condition for fruit production.

45. Green Manures for Groves.—Leguminous cover crops will supply the soil with nearly all the nitrogen the trees will need, and there will be no expense except for the seed of the cover crop. The cover crop can be supplemented with applications of phosphoric acid and potash. As a general rule, about 25 pounds of acid phosphate or ground bone and 5 or 6 pounds of sulphate of potash per tree in a mature grove added during the summer will supplement a leguminous cover crop. However, in case the trees are lacking in wood growth, a slight application of nitrate of soda or of sheep manure might also be added to good advantage.

46. Stable Manure for Citrus Groves.—The use of a judicious amount of stable manure is often advisable in citrus groves in the West. The average application is about 12 cubic feet per tree per year. Some growers apply only 10 cubic feet; others apply 14 cubic feet and do not find the quantity excessive. It is claimed by horticulturists that under some conditions the excessive use of stable manure for citrus trees will cause the production of coarse fruit with thick, puffy rinds. But this effect is not likely to occur in the West. In fact, stable manure is so scarce there that there is little danger of using too much of it. Manure is shipped annually from Los

Angeles and other cities to the groves of California. One grower at Riverside has a standing order with a livery stable owner in Los Angeles for a given number of cars a year. Unless some such arrangement is made, the average grower will have difficulty in securing much of a supply. The price of manure from the cities depends largely on the freight charges.

Sheep manure is used by many growers as a nitrogenous fertilizer for citrus trees. It is rich in nitrogen as well as in organic matter, and is, therefore, especially desirable when a highly nitrogenous organic fertilizer is required. The usual application is 10 to 15 pounds per tree per year, although as much as 50 pounds per tree, if it is worked well into the soil, could be used if the tree seemed particularly in need of this kind of fertilizer. When purchasing sheep manure, the grower should be sure he is getting manure of good quality, for there is much on the market that is inferior.

47. Commercial Fertilizer for Groves.—Many growers resort to the use of commercial fertilizers as a source of plant-food, thousands of tons being used by growers annually.

The best fertilizer experiments in California are those now being conducted at the Riverside Experiment Station, by the University of California. There are twenty-two different plots of considerable size on typical soil of the Riverside-Redlands section. Up to the time the trees were 6 years old and bore considerable fruit, it was absolutely impossible to see any difference between the trees on these twenty-two plots, when yields of fruit were compared. The seventh year the trees on the plots that had received no fertilizer were apparently a little lighter green and the fruit somewhat smaller, although of good quality, than on the fertilized plots. A desirable physical condition and high humus condition was maintained on the experimental plots. No plow sole had ever been allowed to form. Several of the trees have been dug up, and their root systems found as nearly perfect as could be desired.

From the results of this experiment it would seem that there is little need of fertilizing young orange trees with commercial fertilizer when they are grown on ordinarily rich California

soils. After the trees are 5 or 6 years old fertilizer can be used if the soil and trees seem to demand it. No general fertilizer formula can be given that will apply to all conditions, but as a guide it can be said that a mixed fertilizer containing 4 per cent. of nitrogen, 12 per cent. of phosphoric acid, and 5 per cent. of potash will generally give good results. Starting with 4 or 5 pounds per tree per year for 4-year-old or 5-year-old trees and increasing the quantity 1 pound per tree each year will usually be sufficient. For mature trees, 20 to 25 years old, 20 pounds per tree is the usual application made by growers. The quantities given are merely guides and should be varied to suit the condition of the trees. Many growers make two applications of fertilizer a year, one in the spring and the other in the summer, some time from May to August, the exact time depending largely on the condition of the trees. The fertilizer applied in the spring can be broadcasted just before the cover crop is turned under, and thus it will be placed underneath the furrow slice. The summer application can be broadcasted before a cultivation of the grove and it will then be worked into the soil by the tillage implement. Other growers make but one application a year, the fertilizer being put on just before the cover crop is turned under. Many growers contend that nitrogen assists the tree in setting a large crop of fruit, and it is a custom to apply 2 or 3 pounds of nitrate of soda to mature trees just before they come into bloom.

Many growers, instead of buying ready-mixed fertilizer, get the fertilizer ingredients and either mix them or apply them without mixing. Mr. C. C. Chapman, of Fullerton, California, uses the following method for a grove of 21-year-old trees on soil that is kept well supplied with humus: In February or March he drills into the soil from 20 to 25 pounds of 9 per cent. tankage per tree; at the blossoming time of the oranges he spreads on the ground from 4 to 6 pounds of nitrate of soda per tree; during July, August, or September, depending on the condition of the trees, he drills in from 15 to 20 pounds of ground bone and 5 pounds of sulphate of potash. The humus content of the soil in his groves is kept up by the use of stable manure and leguminous cover crops.

48. Combinations of Fertilizers.—Most successful growers use combinations of the different fertilizing materials. Many use stable manure and commercial fertilizer, and grow some leguminous cover crop. One successful grower uses commercial fertilizer rather freely each year, grows a leguminous cover crop in the winter, and applies stable manure or sheep manure whenever he thinks his grove is in need of such a fertilizer. Another grower uses stable manure one year and commercial fertilizer the next year.

It is interesting to note the following paragraph on the fertilizing of a grove, from a report published by the Riverside Horticultural Club, California:

> What kind of fertilizers are the best, and how and when they should be put on are questions often asked, but never as yet answered to the satisfaction of all. It is known that the different ready-mixed commercial fertilizers on the market are good, and when freely applied they generally give satisfactory reults. But growers believe that they are too expensive, and that buying the chemicals and doing their own mixing, or by applying the chemicals in suitable quantity to the soil without mixing, they may reduce the expense about one-half. There is a growing conviction among orchardists that stable manure is one the most valuable fertilizers when it can be secured at reasonable figures. One small navel orchard in Riverside, 15 years old, a part of which has been fertilized exclusively with stable manure, has borne regularly, and the fruit has been fully up to the average standard of quality.

COMBATING PESTS IN GROVES

49. Spraying Trees.—Orange growing, like the growing of all fruits, is beset with difficulties occasioned by insects and fungi. However, under irrigation, the need for spraying to combat the pests is less pronounced than with most other fruits. As will be learned by studying the methods for controlling the pests given in a subsequent Section, the red spiders, mealy bugs, thrips, and a few fungous troubles are, as a rule, the only ones that require the use of a spray. Descriptions of the pests, the time of year for the spraying, and the methods in use are given in that Section.

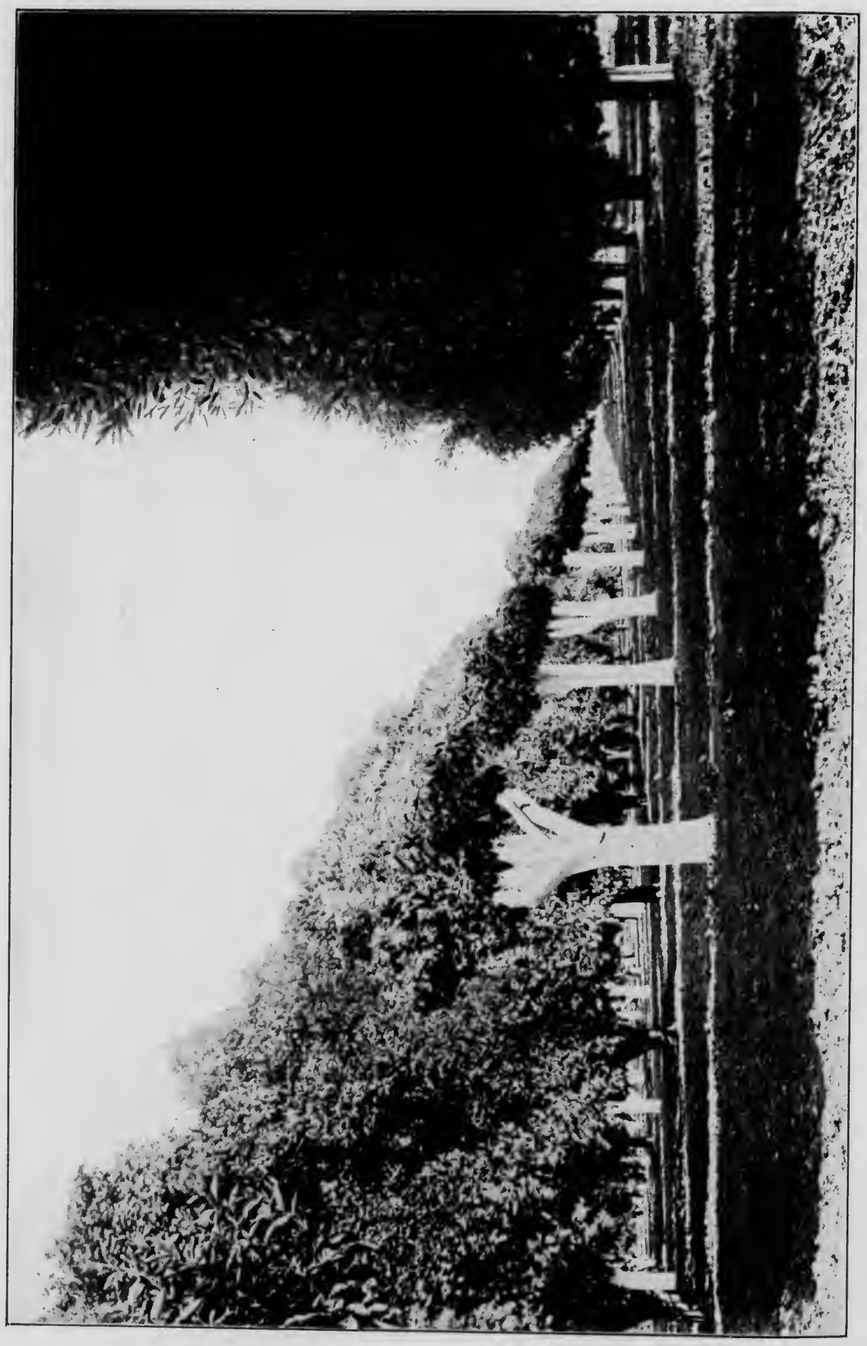

FIG. 35

50. Fumigating Trees.—A detail of management that is not generally employed in fruit growing, except for citrus fruits in the West, is the fumigation of the trees with hydrocyanic gas for controlling scale insects. Where these pests are troublesome in California and Arizona, the trees should be fumigated at least every other year, and occasionally oftener. The details of fumigation are described in a subsequent Section.

51. Combating Rodents.—In the citrus regions of the West squirrels and gophers are sometimes pests that must be combated. Especially are they troublesome in newly planted regions. The details of combating rodents is also given in a subsequent Section.

BUDDING OVER TREES

52. Mature citrus trees can be budded over from one citrus variety to any other citrus variety. For example, a certain variety of orange can be budded over to another variety of orange, or the orange can be budded to the lemon; the lemon to the grapefruit; the orange to the lime, citron, etc. In Fig. 35 is shown 40-year-old seedling orange trees budded over to Valencias, and in Fig. 36 is shown a mature Valencia tree budded over to lemons. A grower near San Dimis, California, has budded a tree to twenty-two varieties of citrus fruits, including different varieties of oranges, lemons, pomelos, limes, citrons, etc. Such a tree, although it has little commercial value, shows how any citrus variety can be budded on any citrus stock.

The fact that citrus trees can be so readily budded over is often of much commercial advantage to a grower. For example, if he has a number of old seedling trees he can bud them over to Bahias, Valencias, or lemons, which are more profitable to grow. The buds can be inserted into the bark of old branches or into the bark of twigs. The former method is most commonly practiced, as it is the quicker way to secure a new tree. When working on old wood, the bud is generally inserted in large limbs near the crotch. The work of budding over trees can be done in the fall and the buds allowed to lie dormant

until the flow of sap in the spring, or it can be done in the spring when the sap flow is strong.

53. The method of inserting the bud and wrapping the stem is similar to that followed when budding seedlings in the nursery. If the budding is to be done in old bark, an older bud with a larger, thicker shield is taken than when budding a twig.

FIG. 36

The bud sticks are cut and placed in a damp cloth. In the bark of the limb to be budded is made the **T**-shaped incision as when budding nursery stock; the bud is cut from the bud stick and slipped into place. Waxed cloth $\frac{3}{4}$ inch in width is then wrapped about the branch in a manner to hold the bark firmly over the bud. Usually in from 10 days to 2 weeks the branch

above the bud is either cut off or girdled. Some persons cut the branch off just above the bud; others cut it off at a distance above the bud and then after the bud has started growth they remove it just above the bud; still others girdle the branch above the bud—that is, cut out a ring of bark around the branch.

FIG. 37

If the bud is inserted in the fall, the top is not usually cut back until the fruit that is on the tree above the bud has been gathered. The wounds caused by removing the branches should be protected by covering them with a wound dressing of hot grafting wax applied with a brush, or some kind of paint. Fig. 37 shows a Bahia tree budded over to lemons, 18 months

from budding. Fig. 38 is a nearer view of a tree in the same grove. At *a* can be seen where the bark on the limb was split when the bud was inserted; at *b* is shown a bud that did not take; the stubs *c* should be sawed off.

After the bud has been inserted, the trunk of the tree and the bud itself should be whitewashed to prevent sun scald. If the branch above the bud is removed at once the whitewash should cover the whole part of the tree below the wound. In Figs. 35, 36, 37, and 38 the whitewashed trunks can be seen. The most satisfactory whitewash is a Bordeaux mixture made of 1 pound of copper sulphate and 2 pounds of unslaked lime, with water sufficient to make a thick mixture that can be applied with a brush.

FIG. 38

In from 10 days to 2 weeks after the whitewashing the muslin tape should be removed from the bud. Suckers that form below the bud should be removed and the growth from the bud itself should be pinched back, if necessary, to induce low branching.

In twig budding, the bud is removed from the bud stick with a large amount of bark and the wood beneath the bark carefully removed, leaving the tissue around the bud nearly all bark. A **T**-cut is then made in the twig to be budded and the bud is inserted and tied as when seedlings are budded in the nursery. At the end of about 2 or 3 weeks if the bud takes, the tape is removed and a part of the stock above the bud cut off to induce a flow of sap into the bud. As the growth from the bud develops, more and more of the stock is removed until the budded part is able to use the entire flow of sap, when the stock is cut off smooth and close to the bud. This is necessary, in order that the wound will heal quickly.

MECHANICAL PROTECTION OF TREES

54. Protecting Tree Trunks.—The trunks of young citrus trees should be protected from the sun and from the formation of suckers by some mechanical form of tree protector.

FIG. 39

FIG. 40

A simple and efficient protector can be made from old fertilizer or barley sacks tied loosely but securely around the trunks up to the desired height. Fig. 39 illustrates a young citrus tree wrapped in this manner. Thin sheets of yucca wrapped around

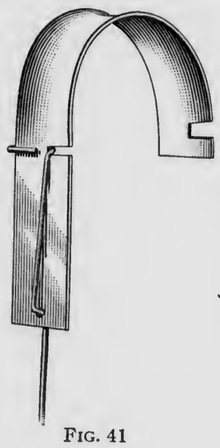

FIG. 41

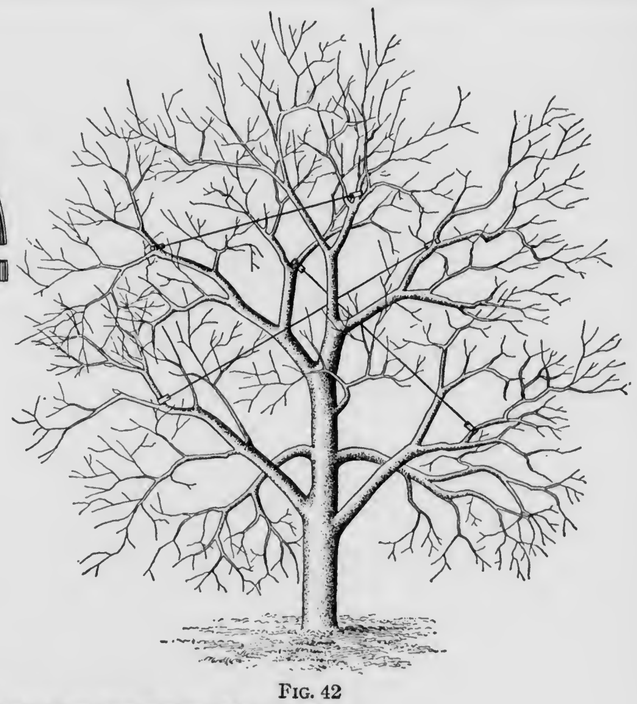

FIG. 42

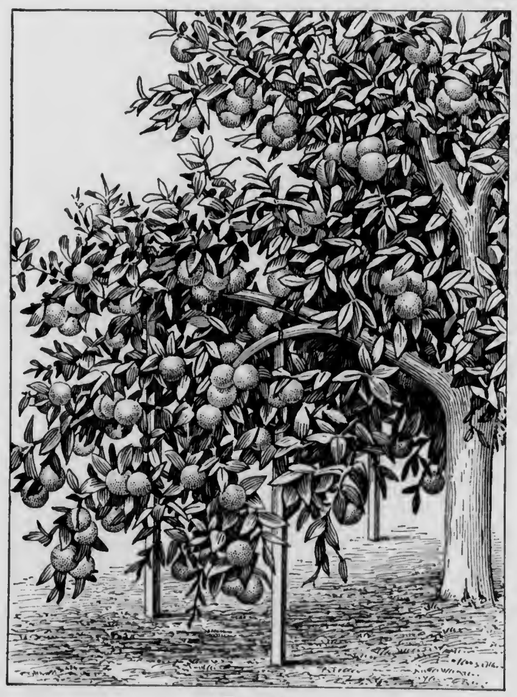

FIG. 43

the tree and fastened as shown in Fig. 40 is also a good means of protection. These yucca tree protectors can be had with wires attached for use. Several other styles of tree protectors are on the market, and can be purchased from dealers in fruit growers' supplies.

55. Protecting Loaded Trees.—Citrus trees when loaded with fruit often require protection to prevent the breaking of branches, although, if they are properly pruned and headed low, less protection is necessary than when these precautions are not taken. One of the best means of protecting loaded trees are hooks like that shown in Fig. 41, hooked into the branches and connected by wire, as shown diagrammatically in Fig. 42. The limbs are then held in place and there is very little abrading of the bark of the branches.

Props extending from the ground to the limbs, as shown in Fig. 43, are used by some growers. Near the top of the piece of wood is clamped a hook, as shown in Fig. 44; this hook is placed under the branch to be held up. Disadvantages of props are, that they interfere with cultivation and cause considerable abrading of the bark of limbs.

FIG. 44

CITRUS FRUITS UNDER IRRIGATION

(PART 3)

LEMON CULTURE

1. The growing of lemons on a commercial scale is of much importance in certain sections of California. According to a statement made by G. Harold Powell, general manager of the California Fruit Growers' Exchange, the lemon comprises from 10 to 15 per cent. of the citrus crop. The lemon is more easily injured by frost than the orange or the grapefruit, and as the tree is in blossom and fruit practically the entire year, it requires about one-third more water in the soil than is necessary for the other kinds of citrus fruits. Thus, it is obvious that not all locations adapted to citrus culture are adapted to lemon culture. For this reason the industry is very largely localized.

The profit from an acre in lemons is said to be greater than the profit from a like area planted to oranges, and as the fruit is picked every month or six weeks during the year, the labor problem is more easily solved than for oranges, which are picked only during a certain season. For these reasons lemon culture, where conditions are favorable, is often more desirable than the culture of oranges.

2. Varieties of Lemons.—The commercial varieties of lemons grown in California are the *Eureka*, the *Villafranca*, and the *Lisbon*. The Eureka variety is the most largely planted, although many commercial groves contain trees of

FIG. 1

the other two varieties. The Ponderosa variety, which, as the name indicates, produces fruit of large size, is grown to a limited extent in home plantings, but is not rated as an important commercial variety.

3. The **Eureka** variety originated in 1870 from a seed planted by C. R. Workman in Los Angeles. All the stock

FIG. 2

plants were later bought by Thomas A. Garey, a nurseryman, who sold plants of the variety widely under the name of Eureka. The trees of this variety are very free from thorns and are vigorous growers and heavy bearers, but they are not particularly heavy in foliage. This last quality is shown fairly well in Fig. 1, which is from a photograph of a bearing Eureka

tree. The fruit of the Eureka is of medium size, somewhat elongated in form, has a sweet rind, a good flavor, abundant juice, and but little of the fibrous material called rag throughout the pulp. It shows few seeds, and keeps and ships well. In Fig. 2 is shown a branch of five lemons of this variety. The elongated form is very apparent in the illustration.

4. The **Villafranca,** a variety imported from Europe, is grown to some extent in California. The tree is thornless and has spreading, somewhat drooping, branches, and abundant foliage. The fruit is medium in size and somewhat pointed at the blossom end. The shape and pointed feature can be

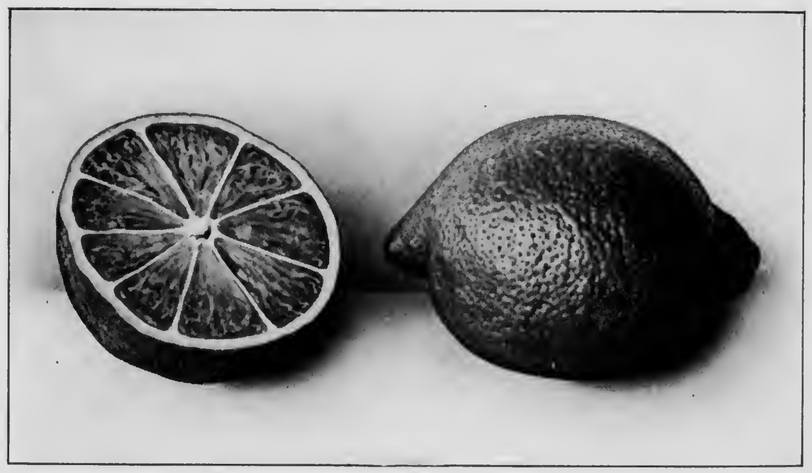

FIG. 3

seen in Fig. 3, which shows lemons of this variety. The fruit is juicy, nearly seedless and of good flavor; the rind is thin and not bitter.

5. The **Lisbon** is a variety that was imported from Portugal and first grown in the Riverside district of California. The tree is a strong grower, has a dense foliage, and is thorny; it comes into bearing somewhat later than the other varieties described, but when mature is very prolific. The fruit is of medium size, somewhat oblong in form, has few seeds, abundant acid, and a thin, sweet rind. The variety is more popular

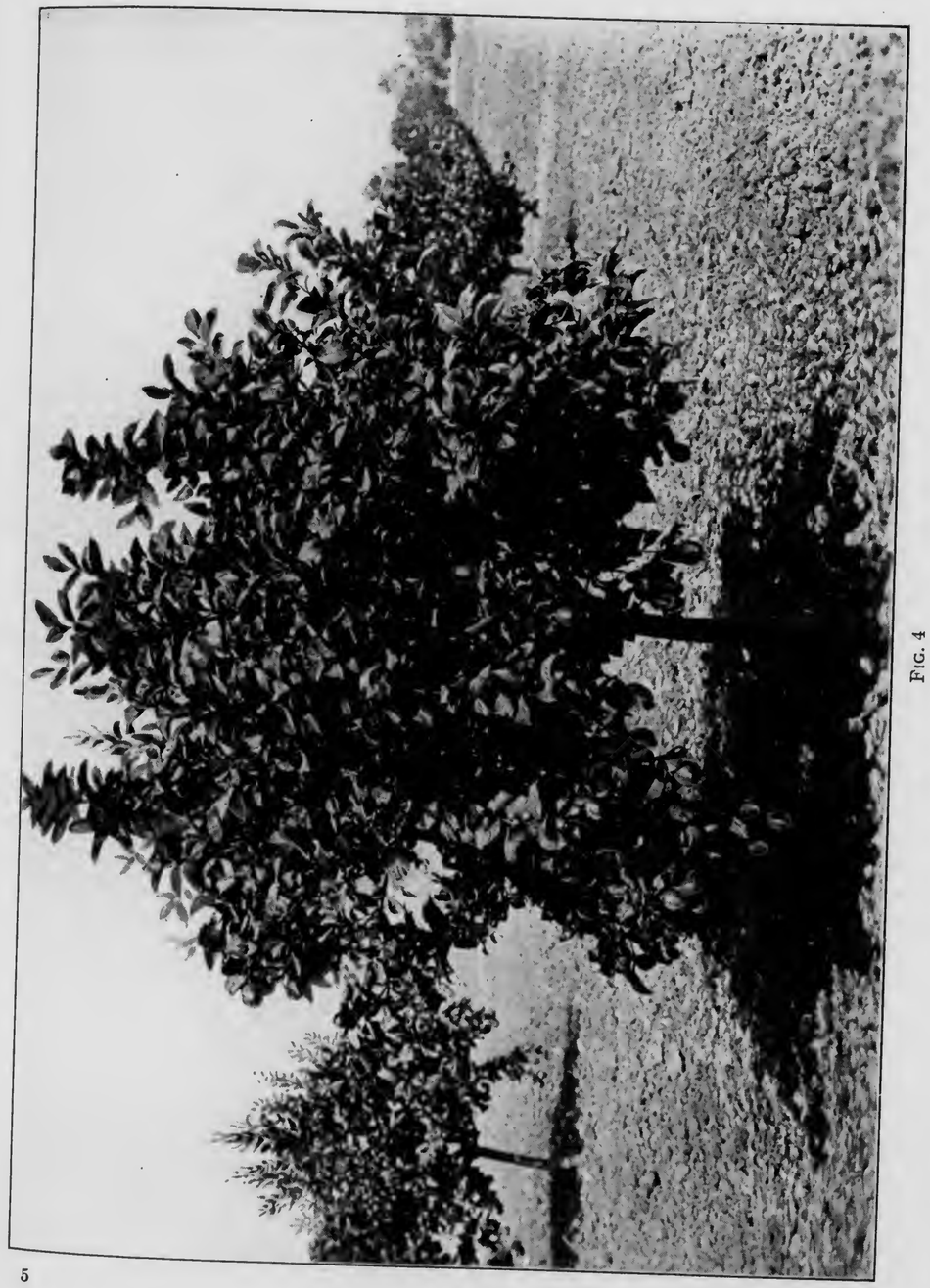

FIG. 4

near the seacoast than inland. A vigorous 3-year-old Lisbon tree is shown in Fig. 4. The rather heavy, dense character of the foliage can be seen in the illustration. A lemon of the Lisbon variety is shown in Fig. 5.

6. Selection of Locality and Site.—The lemon will not stand as low a temperature as the orange, hence its planting for commercial purposes must be restricted to localities where the temperature during the winter months is not likely to go lower than 28° F. They thrive best where the temperature is fairly equable—not too cold in winter and not too hot in summer. Such locations can be found in certain sections of

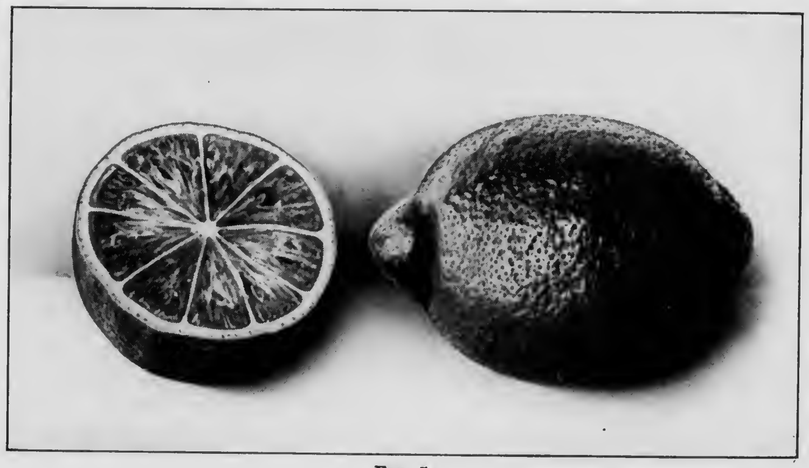

FIG. 5

Southern California both near the coast and inland, and, also, in some of the interior valleys of Central California where the topographical features modify extreme climatic conditions to a certain extent.

In selecting a site for lemon growing it is well to spend much time in studying the local conditions of the district. The most important factors to consider are the elevation of the site, the presence or absence of cold air-currents from the foothills, the quantity of water available for irrigation, the type of soil, the prevalence of pests, the exposure to excessive prevailing winds, the distance to the packing house, and the character of the roads. All of these have been discussed for oranges,

and as they apply equally well for lemons, it is not necessary to repeat what has been said.

7. Propagation of Lemons.—The method of propagating lemons is the same as described for oranges in a previous Section. When nursery stock is budded, the bud should be placed high on the stock in order that the bud union will be high above the ground when the tree is planted. This, as is explained in a subsequent Section, is a preventive measure used against gum disease. Growers will often find that nursery men object to placing the bud high, since greater pains must be taken to have the trunk of the tree straight; the practice should, nevertheless, be insisted upon.

8. Planting the Trees.—Lemon trees should be planted at least 24 feet apart, and many growers, on account of the spreading habit of the trees, prefer them to be 30 feet apart. The time for planting, the arrangement of the trees in the groves, the preparation of the soil for planting, and the methods of placing the trees in the ground are the same for lemons as for oranges.

9. Cultural Practices.—The practices in tillage, fertilization, use of cover crops in the groves, and budding mature trees is practically the same for lemons as for oranges. Irrigation methods for lemons and oranges are similar, but lemon trees, on account of bearing fruit all the year, require slightly more water. In the matter of pest control, practices for oranges and lemons are very similar; however, a few pests are more serious on lemons than on oranges, gum disease, for example. Descriptions of the pests and methods for their control are given in a subsequent Section.

10. Pruning of Lemon Trees.—The subject of pruning is a matter of great discussion among fruit growers. From the individual who regards pruning as a violent unnatural process, to the most ardent advocate of severe pruning, all shades of opinion are represented. No two trees present quite the same problem; no two pruners have quite the same ideal of what a perfect tree ought to be, and too frequently no clear

and well-defined ideal of any kind is present in the mind of the pruner. Pruning may be done for a number of different purposes. Hence, it is not to be wondered at that opinions concerning this important operation are many and at times contradictory.

Some of the different pruning problems of the lemon are discussed in the following pages. It will easily be seen how impossible it is to lay down a definite rule and to state that the lemon or, in fact, any tree should or should not be pruned a certain way. It is the purpose of the examples of pruning for the lemon cited in this Section to present the matter in such a way as to make suggestions and to formulate such principles as will enable the commercial lemon grower to interpret correctly his own pruning problems and solve them with a clear understanding of the needs of each tree involved and the results to be attained.

11. The first pruning the young lemon tree receives is, strictly speaking, that given in the nursery when the head of the tree is formed. This consists in cutting off the top of the tree when the desired height is attained, as explained in a previous Section. On these young trees the main branches should be distributed around the upper part of the trunk as much as possible, at intervals of about 6 inches between each branch in a vertical direction. It is important to space the main branches properly, with no two starting at the same height. Experience with old trees that have the main branches starting from about the same height shows that splitting is almost sure to occur sooner or later and that bolting is necessary to hold the tree together. Such main branches should have a firm grip upon the trunk; there is then less danger, when they come into bearing, of breaking down under a load of fruit.

There are many arguments both for and against low-headed trees. An argument against them is the difficulty of doing the necessary hand work under the branches, such as treating gum disease, and cultivating near the trees. Where brown rot and other fungi infest the soil and attack both the fruit and the trunk, the lower branches will necessarily have to be pruned away and the ground underneath sprayed in order to prevent

infection. The principal arguments, on the other hand, in favor of low-headed trees are that the trees are easier to prune and fumigate or spray; fruit is harvested more readily; the fruit is not so liable to be whipped about by winds and bruised; limbs are not so liable to break and the trunks of the young trees are less liable to sun scald. Heading of trees is a matter that the individual grower must settle for himself according to his own judgment. However, regardless of the height trees are headed, the principles of forming the top of the tree are the same, and the tree should be pruned so that the main branches will be as strong as possible.

12. The lemon tree requires vigorous pruning, and in order to get the best results, the tree should be pruned regularly from the first year after planting. The nature of the tree is to make a strong, upright growth and the fruit has a tendency to grow on the ends of that growth, so that the fruit, if allowed to develop there, is bruised by the wind and the limbs are broken under the load. The checking of this heavy growth by pruning causes the development of numerous lateral fruit-bearing branches. The fruit is set in close to the center of the tree and there is no danger of its becoming scarred and whipped around as it would be if on long, spindling branches. A prominent lemon grower has suggested the following practice in pruning: Desirable leaders should be cut back one-half or more, while undesirable shoots should be removed entirely, leaving only such branches on the trees as will form a symmetrical head. The new growth had better be let alone until it has stopped growing and hardened up. Young, tender growth, however, may be checked and made more stocky by pinching it back at the tip.

The pruning of lemon trees should be done with the object of preventing any of the trees from growing too dense either on the sides or at the top, so that the light from above can penetrate through the foliage and appear in patches on the ground; such a condition is best for the setting of fruit on the inside. By encouraging a certain amount of healthy fruit wood on the top of a tree, the grower can discourage the rapid

growth that is so commonly seen on trees pruned with a wide open center and flat top.

In Fig. 6 a well-pruned lemon tree of the Eureka variety is shown. The branches are well distributed on the trunk of the tree. Notice how the light shines through branches and appears as patches on the ground.

13. The tools, ladders, wound dressings, etc. used in the pruning of orange trees are obviously the kind employed for lemon pruning. The best time for pruning lemons is in the

FIG. 6

late spring and early summer when there is the least fruit on the tree. The heaviest pruning should be done when the least sap is flowing or when the tree is most dormant. The method of procedure in pruning lemon trees is for the pruners to go under the tree first, take out the dead wood and thin out the dense branches that cross or interfere with others. Then the top is cut back with long-handled shears; some branches are merely shortened; others are cut back to the point from which they originate. Ladders are, of course, necessary for the pruning of the top branches of most trees. In addition to this regular pruning, suckers must be removed whenever necessary.

Systematic pruning of the lemon not only brings the tree close to the ground, thus materially reducing the cost of picking, but also tends to cause the tree to be more prolific and produce a better quality of fruit.

The practices in pruning suggested by a prominent lemon grower, mentioned in a previous paragraph, are most used at present in California. There are several well-defined systems of pruning which have been used in the past. It will be well to consider a few of these systems briefly, because many of them have a certain degree of merit. They also illustrate the many ways that lemon trees can be pruned.

14. What is known as the **Baronio system** of lemon pruning was introduced into San Diego County, California, by A. C. Baronio, an Italian, who considered it especially adapted to the lemon as grown in the southern part of the state. He aimed to produce a broad, low, open tree, every part of which could be reached by a person standing on the ground. The main limbs spread horizontally and were considered to be strong enough to bear a great weight of fruit and the force of considerable wind without breaking. The system was based on certain physiological principles, some of which are: (1) A lateral branch is more fruitful than an upright branch, as there is a greater elaboration of plant-food for the production of fruit in the former than in the latter. (2) Fruitfulness and excellence are the results of a slow but steady circulation. (3) The top of a tree must not be allowed to outgrow the root system, but should form only sufficient wood to keep it growing and producing fruit according to its size and age. (4) A limb is less liable to split off if it joins the mother limb at an obtuse rather than an acute angle. (5) Foundation branches can never be built too strong; there must be no weak points about them. (6) Since main branches are broken mostly by vibration and not by mere weight, such branches should be so stiff that they will not be affected by vibration.

In order to obtain the desired growth and shape of the tree by this system, the trunk is headed back to 16 inches, which

is considered the best height. Three of the shoots that appear are allowed to run straight up until they are well grown, when they are arched over toward the ground; they are then fastened in this position until held there by the natural growth of the wood. On these three main branches secondary branches are allowed to form, and these are also arched over and later headed back to form the spreading horizontal growth desired.

While the Baronio system has many points that are commendable, and for the most part is based on right principles, its main defect is that it does not provide a sufficient vertical space for the development of fruiting wood. It is particularly adapted to shallow soils that are incapable of maintaining a large-sized tree.

15. The **open-center system** of pruning is a modification of the Baronio system. The central part of the top is removed entirely and thus the sap is thrown into the lower horizontal branches, where good fruiting wood is secured. The appearance of an open-centered tree, when viewed from above, is that of the inside of an inverted cone, with the surrounding branches pruned back to a definite limit in height. The after treatment in this system consists in the removal of the vigorous upright branches that appear in the open center and the retention of the fine fruiting brush that soon thickly clothes the main branches. By successive prunings, the main branches are trained out and up by cutting to inner or outer buds as the case may require. The resulting wood is crooked and angular but tends to the production of abundant fruit spurs. The branches secured by such treatment are well braced and bear the weight of fruit without propping or sagging entirely to the ground. The prime object of the open-center system of pruning is to get, as far as possible, all fruit wood and no unfruitful wood, and to have all the tree producing something so that there will be no drain on the root for useless timber. Such restriction of wood growth, however, may be carried too far, and the tree often shows its resentment of such interference by a less thrifty appearance and smaller crops. A more abundant growth of foliage must then be allowed to develop, so that the failing root system will have more elaborated plant-food to draw upon.

16. The **closed-center system** of pruning has in times past been used to a limited extent in the lemon groves of California, but it is now little used. The closed-center system, as its name implies, leaves the space in the center of the tree filled with the upright branches. If these branches are kept properly thinned out the results will be good; if they are allowed to become too thick, the production of inside fruiting wood is discouraged.

17. The **Semi-Baronio** system consists in removing the centers of old trees and allowing the air and light to penetrate. The other branches are kept cut back but not so closely nor so systematically as in the true Baronio system.

18. What may be called the **shearing system** of pruning is sometimes used by growers, but its use cannot be too strongly condemned. It consists in shearing off the top of the trees so that they are perfectly flat. This tends to produce a dense growth in the top of the trees, and such a growth is not at all conducive to good results in the matter of obtaining fruiting wood. Such trees are pleasing in appearance, and catch the eye of the tourist, but they do not produce paying crops of fruit.

19. The **open horizontal system** of pruning is a compromise between the Baronio system and the shearing system. As in the Baronio system, the horizontal branches are pruned for fruit and the strong, upright secondary growth suppressed. This system is not used in commercial groves at the present time.

20. In general, it may be said that although there are many different systems of pruning lemon trees, the principles are practically the same for all, and if they are followed the pruner will not go far astray. Some of the most important of these are:

1. Shape the head at the proper distance from the ground and aim to get the main branches located on the tree in such a way that a good, strong framework is secured for the tree.
2. Have a definite ideal in mind as to what the tree is to be like when mature, before the first pruning, and throughout the life of the tree prune according to that ideal.

3. Study the natural fruiting habit as well as the individuality of the tree, and prune to remedy its defects.

4. All pruning should be done with a definite purpose in mind, the aim being to put the tree in condition to produce and carry the largest possible amount of high-grade fruit.

5. An annual light pruning is more beneficial to the tree than periodical heavy prunings.

6. Avoid making large openings in the foliage of the trees that permit the sun to shine directly on the interior branches. Limbs thus exposed to the hot rays of the sun are very liable to injury from the sun.

7. Limbs that cross and chafe other limbs should be removed when they are small.

8. Dead branches should be removed and burned, because they interfere with the picking of the fruit and harbor insects and fungi.

9. All cuts should be close and clean and the surface of the wound should be parallel to the direction of the branch on which it is located. Stubs should not be left on the tree.

10. All wounds over 1 inch in diameter should be covered over with some kind of a wound dressing.

11. By cutting back to an inner bud, upright growth is secured; by cutting back to an outer bud, spreading growth is secured.

12. The growth of fruiting wood should be encouraged.

GRAPEFRUIT, LIMES, AND CITRONS

21. Grapefruit.—The grapefruit, or *pomelo,* is not grown to nearly as large an extent in the West as are oranges or lemons. Nevertheless, many trees are seen mixed in with orange and lemon plantings, and a few fair-sized groves are found in Southern California. Most of the fruit is consumed locally or in the Western States.

The principal variety grown in the West is the Marsh Seedless. The Triumph, a seeded variety, is grown to a limited extent, and a few other varieties are also grown, but usually for home use.

22. The tree of the **Marsh Seedless** variety is a good grower, comes into bearing early, and is prolific. The fruit is medium in size; it has a thin, light-yellow rind and is generally seedless. Occasionally a fruit is found containing three or four shells of seeds, but usually no evidence of seeds is present. The flesh is juicy and rich in flavor, and of firm texture. The keeping qualities of the fruit are of the best. The bitter quality is not marked. Several Marsh Seedless pomelos are

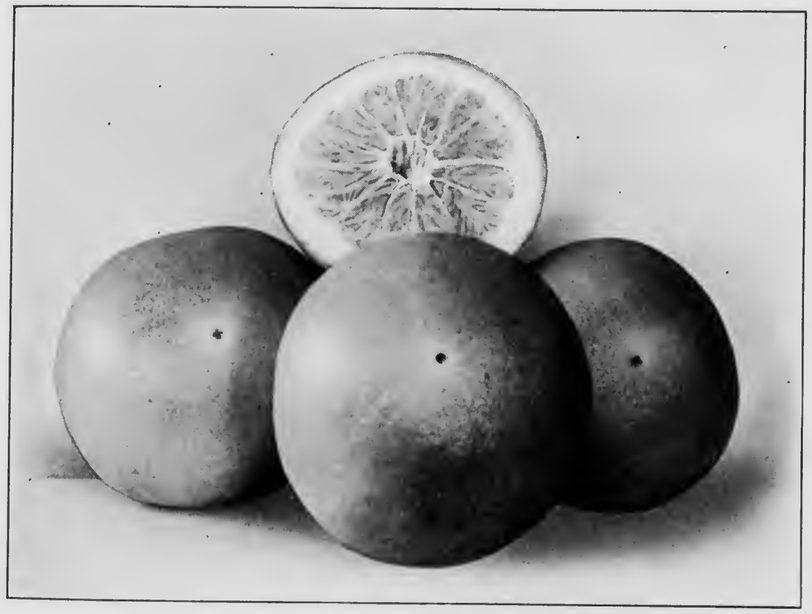

FIG. 7

shown reduced in size in Fig. 7. The seedless character is very apparent in the illustration.

23. The tree of the **Triumph** variety bears early and is prolific. The fruit is round, light yellow in color, of medium size, and good weight. The rind is smooth, thin, and fine grained. Juice of good flavor is plentiful and is free from bitterness. Seeds are few. In Fig. 8 is shown a group of Triumph pomelos considerably reduced. The shape, thinness of the rind, and scarcity of seeds can be plainly seen in the illustration.

24. What has been said of selection of nursery stock, planting the trees, tilling, irrigating, and fertilizing the ground, pruning and otherwise caring for the trees in the discussion for oranges will apply to pomelos. Often pomelo trees are grown in with orange trees and receive the same cultural care They thrive very well under this treatment.

25. Limes.—The lime is a citrus fruit that is little grown in California. It is estimated that there are not more than

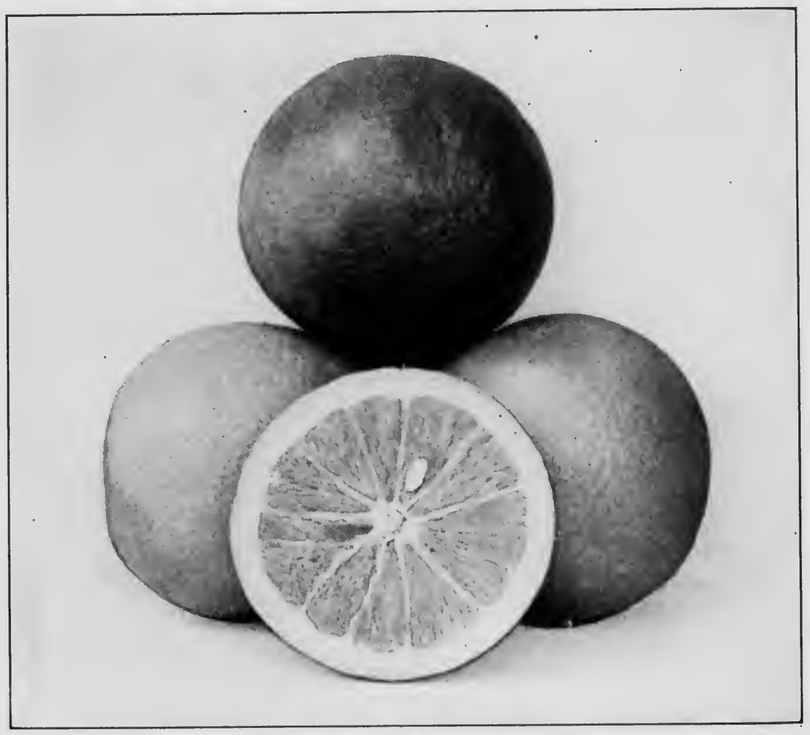

FIG. 8

100 acres of lime orchards in the state, although there are a great many trees scattered about in yards and gardens, especially in those of the well-to-do people of Pasadena, Riverside, and other towns of the same nature.

The lime is very susceptible to frost injury, and as its use is limited, it will probably never be of much commercial importance. The culture of limes is similar to that of oranges.

The Mexican, or West Indian, and the Bearss Seedless are the varieties most largely grown.

26. The **Mexican,** or *West Indian,* variety is the small seeded lime of Mexico, the West Indies, and Florida. It is grown to a limited extent in the West. The tree is small, almost a bush, comes into bearing about the third year after planting, and is very prolific. The fruit is small, but rich in acid, and is very desirable in making beverages.

27. The **Bearss Seedless** variety, largely on account of its seedless character and large size, is planted in the West

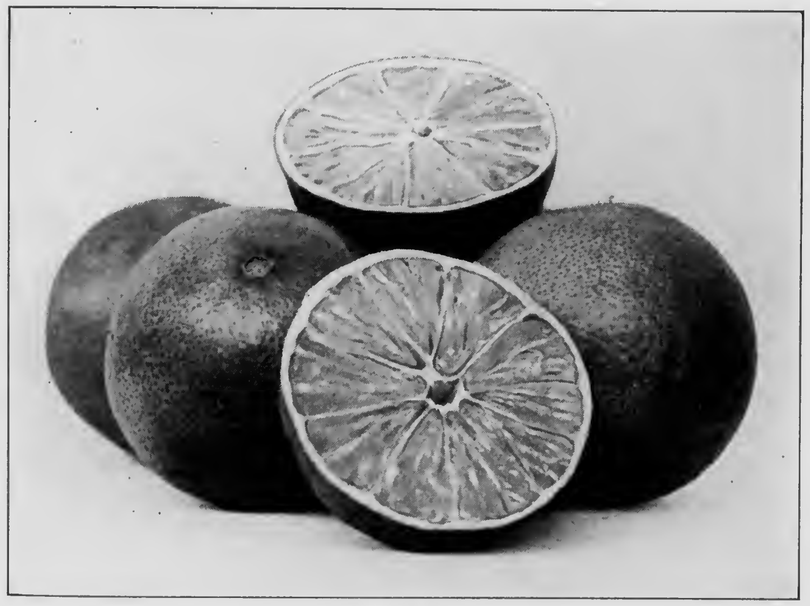

FIG. 9

more than the Mexican variety. The tree is larger than that of the Mexican lime; it is hardy, comes into bearing at an early age, and is very productive. The fruit is about the size of an average lemon; it is seedless, juicy, and very acid. Its use is the same as that of the Mexican lime. In Fig. 9 is shown a group of these seedless limes.

28. Citrons.—The citron is a fruit that is not grown extensively in California. The production is limited to one

or two commercial orchards. There are, however, a few trees scattered about the yards and gardens of various homes. The citron is very susceptible to frost and it has appeared that candied citron can be imported from Sicily into California for less money than it can be produced at home. Experiments have shown, however, that where the citron can be grown, the California product is equal in quality to the imported product. The principal use of the fruit is as candied peel, or rind. In addition, an essential oil can be obtained from the fruit.

29. The **Citron of Commerce** is the variety that has been planted in California. The tree has a low-spreading

FIG. 10

habit, and is very susceptible to frost injuries. It blossoms and fruits at all seasons of the year, and comes into bearing early. The fruit is large, averaging three or four times the size of the lemon; the skin is thick and warty, sometimes furrowed, lemon yellow in color, and has a characteristic odor. The pulp is scanty and less acidic than that of the lemon and shows considerable rag. In Fig. 10 the Citron of Commerce is shown considerably reduced. The thick character of the rind and scanty pulp can readily be seen.

HARVESTING AND PACKING OF CITRUS FRUITS

PICKING THE FRUIT

30. Although citrus fruits do not apparently show an injury as quickly as some of the thinner-skinned fruits, they are, nevertheless, easily injured by careless handling. Extreme care in handling is therefore necessary. This fact cannot be too strongly emphasized. Bruises, clipper cuts, fingernail scratches, and all such injuries cause the fruit to be placed in one of the poorer grades, and in addition, it is very likely to decay in transit, which means loss to the shipper. Experiments conducted by G. Harold Powell, and published in a bulletin by the United States Department of Agriculture, prove conclusively that bruised and scratched fruit is very much more likely to decay in transit than is fruit that is carefully handled.

A grower in California in giving advice about the careful handling of citrus fruit says: "Treat each individual fruit as though it were an egg. Your product will then not only stand up under the wear and tear of picking, packing, and transportation, but will invariably bring you a better price, and enhance your reputation as a grower of fancy fruit."

Some growers harvest and market their own fruit, although there are times when they will contract with professional pickers to do the harvesting. Most growers, however, are members of fruit growers' associations, which hire crews of pickers to pick the fruit for its members if they so desire. These pickers are experts and they can usually harvest the fruit much more quickly and with less injury to the fruit than can the grower himself.

31. Season for Picking.—In the case of oranges, the season for picking the fruit is naturally when the variety is ripe.

For navel oranges, this means that in the northern and central sections of California picking will begin about November 20, and will continue until about January 1. In Southern California, navel oranges are picked from about January 1 to May 1, and in Arizona from about November 15 to January 1. In the northern sections, the period for Valencias is from about March 1 to July 1, and in Southern California from about June 1 to December 1.

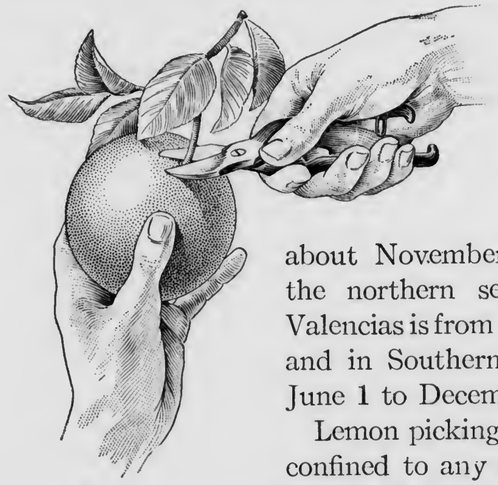

FIG. 11

Lemon picking, as before stated, is not confined to any one season of the year, but the fruit is picked according to size about once a month the year through. Grapefruit is picked during the winter at about the time orange picking is in progress. Limes are picked throughout the year like lemons. Citrons are picked when they have attained sufficient size.

32. Appliances Used in Picking.—Much of the fruit can be harvested by the picker standing on the ground, but ladders are necessary for getting the fruit from the higher

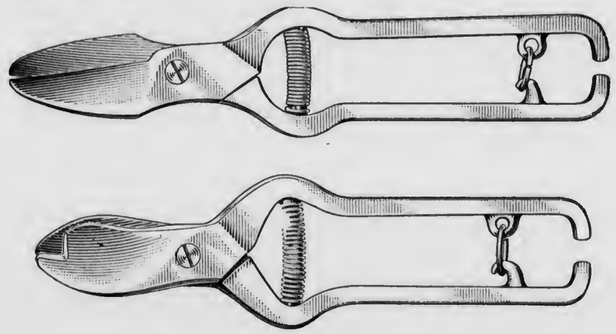

FIG. 12

branches of mature trees. As the trees are usually headed low, step ladders are, as a rule, tall enough. The three-legged

step ladder is desirable, as it will stand more stable on uneven ground than will the four-legged step ladder.

The fruit is removed from the trees by means of clippers, as shown in Fig. 11. Two styles of these are shown in Fig. 12. Many brands of clippers are on the market, but the best ones are those with smooth, rounded points. Some are made with sharp points; these should be avoided, as they are likely to cause many cuts on the fruit. The fruit is removed by cutting it away with part of the stem attached, as this avoids strain

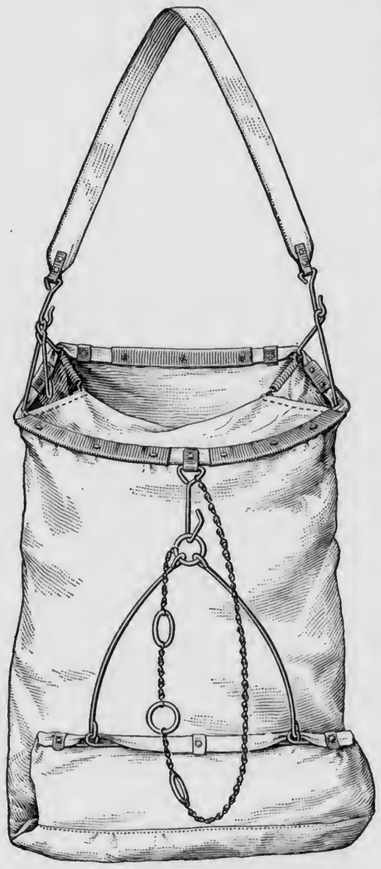

FIG. 13

FIG. 14

on the fruit; the fruit is then held in the hand and the stem cut close to the fruit before it is dropped in the picking receptacle. The reason for this is that long, sharp stems puncture the fruit. In no case should the fruits be pulled from the tree, because the rind of the pulled fruit is apt to be broken, giving a chance for decay to set in.

The picking receptacle generally used in the West is a bottomless bag of the style shown in Fig. 13. These bags are padded and are held closed by fastening the ring to the hook, as shown in the illustration. They are carried over the shoulder, as shown in Fig. 14, and are emptied by unhooking the chain, which allows the fruit to pass out of the bottom. From the bags the fruit is emptied into picking, or lug, boxes, one of which is shown in Fig. 15. When emptying a bag of fruit, the bottom of the bag should be placed down into the box, allowing the bag to rest directly on the bottom of the box. The chain is unhooked and the bag is gently pulled away from the fruit. The fruit should not be permitted to fall or drop into the box. The picking boxes are of such a size that three boxes of loose fruit will usually make about two boxes of packed fruit. The boxes are made with cleats above the ends in order that they can be filled and then be piled one above the other without injury to the fruit.

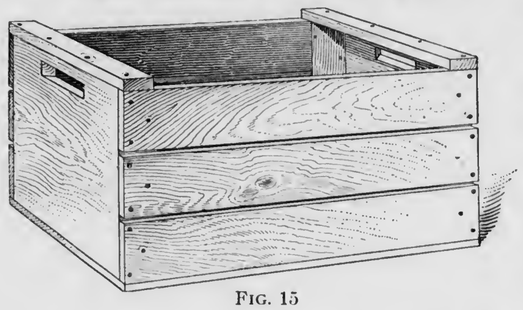

FIG. 15

For picking lemons, use is made of rings such as those illustrated in Fig. 16. These are for the purpose of determining the size of fruit to remove. Rings are made in different diameters, the common sizes being $2\frac{1}{4}$, $2\frac{1}{2}$, and $2\frac{5}{8}$ inches, inside diameter. The ring to use depends somewhat on the time of year, the larger rings generally being used in winter and the smaller ones in summer. This is because lemons are in greater demand in summer than in winter and are, consequently, not given time to attain larger size. The ring is held in the hand, as shown in Fig. 17. When determining whether or not a lemon, as it hangs on the tree, is of the proper size to pick, the ring is shoved up on to the lemon. If the lemon passes through the ring, it is not picked; if it will not pass through, it is removed and placed in the picking bag. A good, healthy lemon when it attains the desired size, is, as a rule, dark green in color. If these lemons were allowed to remain on the tree after they have attained the desired size they would become too large for the best market demands, the skins would thicken, and the fruit would be classed as an inferior grade. Some lemons on the tree will, for some cause or other, ripen before they attain the size desired. These small lemons are picked, but as they are inferior in both appearance and quality to a green lemon properly handled, they constitute a second-grade fruit, and are usually known as *tree ripes*.

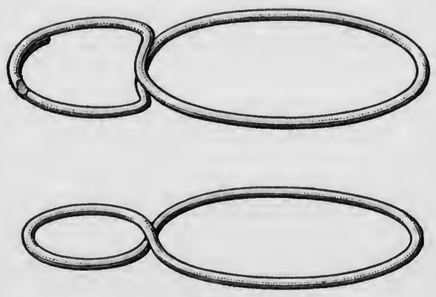

FIG. 16

FIG. 17

The boxes of loose fruit are hauled from the grove to the packing house on wagons provided with springs, the purpose of the springs being to avoid jarring the fruit in the boxes. In California, growers generally use a factory-made wooden wagon with steel skeins, on which they place a flat rack or bed, usually about 8 feet wide and 14 feet long. These racks are made locally and are set on the gears on bolster springs.

GRADING, SORTING, AND PACKING OF ORANGES

33. The grading, sorting, and packing of oranges is done at the packing house. The interior of a large packing house resembles a factory; there are to be seen numerous machines run by power and many workers, each stationed at a given machine or bin doing a certain kind of work. The packing houses are equipped with machines for making the boxes in

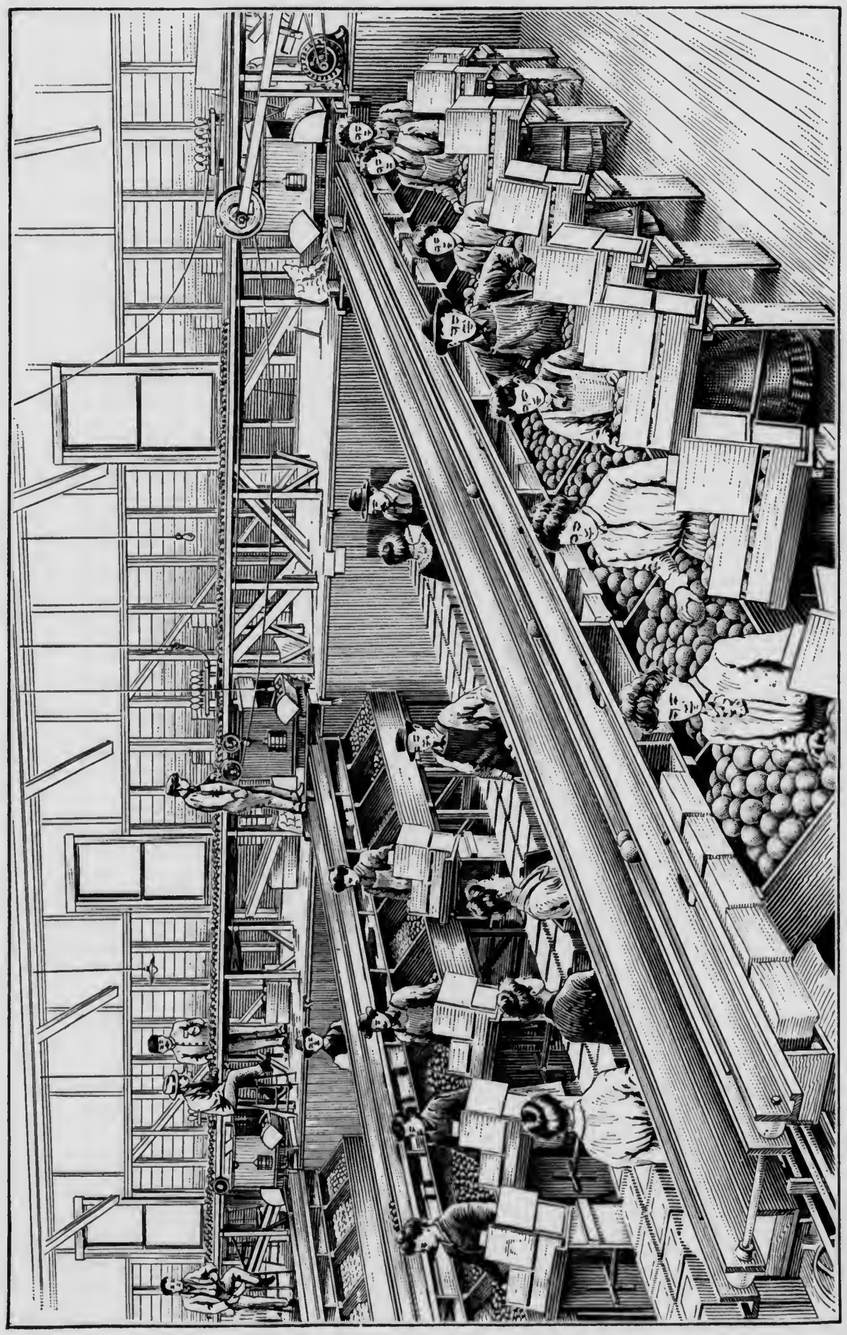

FIG. 18

which the fruit is packed for market, trucks for carrying the boxes to and from the sorting bins, or hoppers; washing tanks and brushes for cleaning the fruit; elevators and belts for conveying the fruit to the different machines; automatic weighing and recording scales; machines used for testing the presence of frosted fruit; belts for carrying the boxes; presses for covering the boxes; in fact, about every kind of practical device that has been invented for handling the fruit can be found in a modern packing house. Fig. 18 is a drawing showing an interior view of an orange packing house in California. From the illustration, some idea of the size and the factory-like appearance can be gained. Numerous manufacturers in the citrus-producing regions of California make a specialty of supplying and installing packing-house equipment, and an association, grower, or packer will have no difficulty in securing the right kind of equipment for installation.

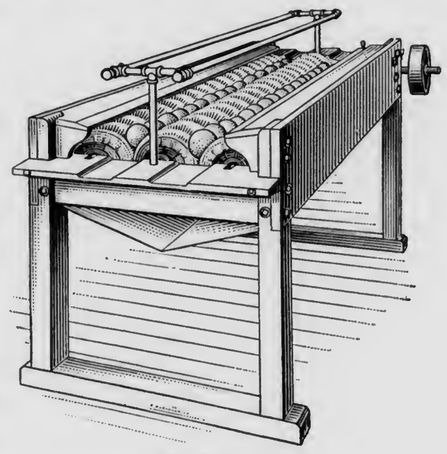

FIG. 19

34. Cleaning the Fruit.—Much of the fruit that arrives at the packing house is dirty or covered with fungi or scales that can be removed. In order to improve the appearance, the fruit is washed and brushed. Machines are on the market that do this work automatically. The fruit is dumped into a tank of water from which it is carried past brushes that rub the surface of each fruit. Some of these machines handle the fruit more roughly than others, and in making a selection of cleaning machinery this matter should receive considerable attention. In Fig. 19 a modern brushing device for cleaning oranges is illustrated. This machine consists of three rows of revolving brushes. The oranges work slowly through the machine in two rows, as shown in the illustration. A spray of water is forced down on the fruit from the pipe shown at the

top of the figure. The revolving of the brushes and the water cleanse the fruit, after which it is conveyed by an elevator or flat belt to the other machines in the packing house

35. Weighing the Fruit.—When fruit is handled by the exchange, it is necessary that the quantity of each man's fruit be known. Automatic weighing machines are usually installed in the packing house for the purpose of determining the weights. The fruit is carried to the machine on a belt, and after a certain amount has collected, the machine is tripped and the amount recorded automatically. In Fig. 20 a modern automatic weighing machine is illustrated. The fruit passes on to the

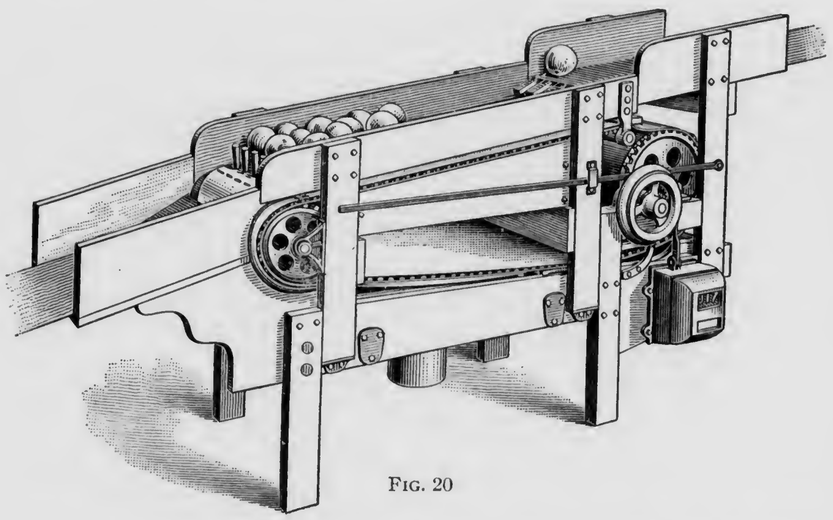

FIG. 20

machine from a slight incline where it is held by pins as shown. The fruit then passes along on the belt to the other parts of the house.

36. Grading the Fruit.—The fruit is graded carefully before it is sized for packing. The usual grades are fancy, choice, standard, and culls. Only such fruit as is considered perfect, that is, free from blemishes, sound in quality, and fairly smooth, is sorted out for the fancy grade. The next best is the choice grade, which consists of such fruit as may be only slightly blemished and possibly not quite so smooth as the fancy grade,

but otherwise sound and of good quality; that fruit which is badly scarred and has a rough skin but is sound and of good keeping quality is packed as standard. Culls are those fruits which show an unsound skin, either from being bruised in picking or handling, and will not keep.

In the packing house the fruit to be graded is usually carried past the graders on flat belts in such a manner that the men can see each fruit as it passes, and as the fruit passes it is separated into the different grades.

37. Sizing the Fruit.—The fruit, after it has been cleaned, weighed, and graded, passes to the sizing machine, where it is automatically sorted to size. A sizer is shown in the lower part of Fig. 18. The fruit carried on a belt passes over a series of openings of different sizes, and as a single fruit comes to an opening through which it will pass, it drops through into a shallow bin. All the fruit in each bin will, therefore, be approximately the same size. The sizes of the openings through which the fruit drops are governed by the number of fruits that can be packed in the standard-size market package.

38. Labeling the Fruit.—A few growers make a practice of pasting a small label to each fruit of the best grade for the purpose of advertising their product. In Fig. 21 reproductions of the label used by C. C. Chapman for his best grade of fruit is shown natural size. The original labels are in color and are very attractive and serve as very useful advertising for Mr. Chapman's fruit.

FIG. 21

39. Wrapping the Fruit.—The packers who place the fruit in boxes for shipment wrap each fruit in tissue paper before placing it in the box. These wrappers bear the name or trade-mark of the exchange, firm, or grower marketing the fruit. The designs are printed in colors and are attractive and become an excellent advertising feature, provided the same quality of fruit is always wrapped in the same kind of wrapper. Several trade-marks from California orange wrappers are shown

in Figs. 22, 23, and 24. The originals of these are in color, but for illustrative purposes they are reproduced here only in black and white. An advantage of wrappers other than the advertising feature is that wrapped fruit is more protected from bruising in transit than is unwrapped fruit. The packers

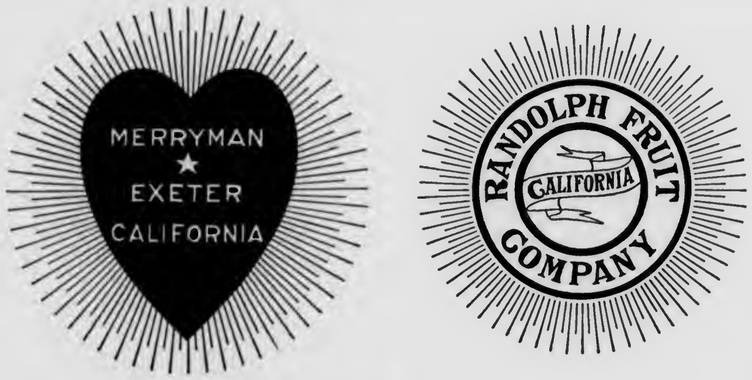

FIG. 22

FIG. 23

FIG. 24

soon become very dexterous in the work of wrapping fruit, and it requires very little more time to pack the fruit wrapped in papers than to pack it without wrappers.

40. Boxing the Fruit.—The fruit is packed in boxes by hand, each packer standing by a bin of the sizer, as can be seen

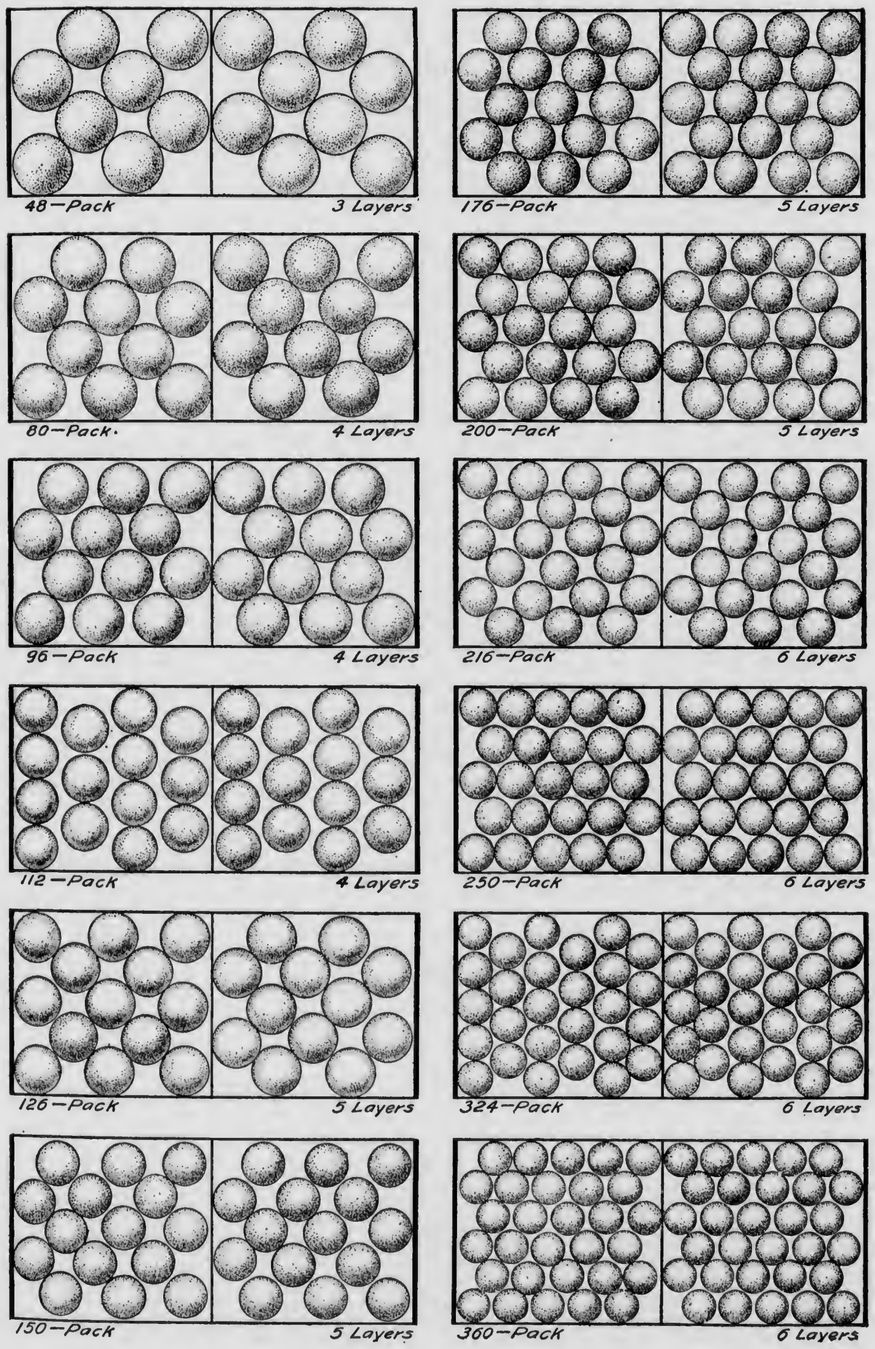

FIG. 25

in Fig. 17. In the West, the standard box used for oranges is 12 in. × 12 in. × 26 in., outside measurements, and is divided into two compartments. This is the type used for all varieties of oranges except tangerines, which are generally packed in boxes of the same length and breadth as the standard box, but of half the depth. These half boxes are cleated together when shipped. All boxes are purchased knocked down and are set up in the packing house.

FIG. 26

The oranges are arranged in layers in boxes and a definite number of a certain size make up the contents of a box. The number in a box ranges from 48 to 360. The standard sizes of fruit are designated as 126s, 150s, 176s, 200s, 216s, according to the number in a box; the "large off" sizes are designated as 48s, 64s, 80s, 96s, 112s; the "small off" sizes are designated as 250s, 324s, 360s. In Fig. 25 are shown the arrangements of the bottom layers of twelve of the most used packs for oranges. Below each drawing is given the number of fruits in the box and the number of layers. In arranging the second and subsequent layers, the fruits are placed to fit down into the spaces between the fruits of the layer below. The fruit should fit snugly in place, but it must not be pressed down too hard on account of bruising. In Fig. 26 is shown a well-packed box of oranges of the 150 size. Note the regularity of the pack and the attractive appearance of the box of fruit.

After the packer finishes a box, it is taken away and an empty one put in its place. Usually one person does the work of removing and replacing the boxes. Often there is a moving

belt back of the packers on which the filled boxes are placed. This conveys them to the box press, where they are covered. The covers are pressed down at the ends of the boxes by means of levers operated by the man in charge of the machine, and the lids with cleats are nailed in place at the ends. The top of a filled box is allowed to bulge in the middle about $1\frac{1}{2}$ inches, as shown in Fig. 27. The cover then presses on the fruit and holds it firmly in place, and thus prevents it from becoming loose in the box. The boxes are placed on end when loaded in the cars, and there is thus no bruising by weight on the curved boards of the box.

FIG. 27

FIG. 28

41. Box Labels.—At the ends of the boxes lithographed labels are pasted. These labels designate certain brands of fruit

FIG. 29

FIG. 30

and the different brands soon become known on the market. Often consignments of fruit are designated by their brands. These labels are a valuable means of advertising the fruit of an association, packer, or grower. In Figs. 28, 29, and 30 are shown three California labels. The originals are in color, but they are reproduced here in black and white simply to show the style of label used for citrus fruit in the West.

LEMON PACKING-HOUSE OPERATIONS

42. Ordinary Curing of Lemons.—As stated previously, lemons, except the tree ripes, which constitute an inferior grade of fruit, are picked green. Before this green fruit can be sold it must be **cured**—that is, subjected to a process that changes the green color to the waxy lemon-yellow color which the market demands. The curing process is a very important feature of the lemon industry, as the color of the fruit is one of the principal factors that determine the price of the fruit on the market. The condition of the fruit when it is picked determines to a large extent whether or not a uniform waxy lemon-yellow color can be secured. For example, lemons that have begun to turn yellow on one side or end when they are picked will usually develop a dull, brassy-yellow color when cured; whereas, if the lemons are uniformly dark green when picked, they can be cured to the desired color. Cured lemons have a better appearance, more juice, better keeping quality, and thinner rinds than tree ripes, and for these reasons constitute a better grade of fruit.

The ordinary curing process consists essentially in holding the fruit for from about 30 to 60 days under the greatest possible uniformity of temperature and humidity. What is known as the open-air method of curing has been found most successful in California. Lemon houses are built only with a roof and floor, leaving off all sides for a free circulation of air. This building is then divided off into individual rooms with canvas sides and tops. In order to facilitate curing the fruit, space is left around each room for a free circulation of air. These

FIG. 29

FIG. 30

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rooms, or tents as they are usually called, are rectangular in shape, and are generally made of a size to hold about one carload of fruit. The four canvas sides and the top are lapped at the corners and are fastened with cords drawn through hooks, and the sides are so arranged that they can be raised or lowered at will by means of cords that pass through pulleys in order to control the circulation of the air among the boxes or trays of fruit piled in each room. When the tents are not in use the sides can be rolled up and the floor space in the curing house used for other purposes if desired.

The trays of green fruit are placed in the curing tents soon after the lemons have been washed. Those trays on the outside and the top of the pile are usually lined with paper. This is done to avoid excessive evaporation and the consequent wilting that is likely to occur to fruit that is in the exposed part of the room.

Light-green lemons can usually be cured in about 30 days, or frequently in less time. The darker fruits require more time, usually about 60 days. The change from green to yellow takes place very gradually. Those in charge of the work must be guided by the appearance of the fruit, the condition of the air in the tents, and the condition of the outdoor air, and ventilate the rooms accordingly. No set rule can be given that will be practicable under all conditions, and each man must, therefore, study his own conditions, and be guided by the knowledge he gains from experience.

43. Forced Curing, or Sweating, of Lemons.—What is known as the forced curing, or sweating, of lemons is practiced when it is desired to cure the lemons in a shorter time than that necessary under the ordinary curing process. By forced curing it is possible to produce the change from green to lemon yellow in from 5 to 14 days. Crop and market conditions are such that were it not for forced curing, lemons would be very scarce in certain seasons. The greatest demand for the fruit is in the summer and fall. Much that is harvested in the winter and spring is stored and disposed of in the summer, but as the season advances the supply from this source

becomes scarce, and then it is necessary to force the curing of the summer-picked fruit, if the trade is to be supplied. By being able to cure the fruit in the ordinary way in from about 30 to 60 days, if desired, or, to cure it by the forced curing process in from 5 to 14 days, the packer has conditions well in hand, and can regulate his marketable stock to meet the demands of his trade. If at any season the demand is not good he can hold back on the curing, or, if it becomes brisk, he can employ the forced-curing process and get the fruit to market in a relatively short time.

44. Forced curing, or sweating, is accomplished by subjecting the fruit to a high temperature and a high percentage of humidity when certain gaseous products are present. There is still much to be learned about the sweating process and the real reasons for certain phases of the process are not understood. Improvements are coming rapidly. Packers and scientists from the government and state departments of agriculture are studying the curing of lemons and many experiments along this line are being performed. The fruit at present is placed in a closely confined enclosure known as the sweat room. These rooms are constructed in various ways. At times use is made of the curing tents of the packing house that are used in the open-air method of curing. When tents are used for the forced curing, the sides are let down to the floor and no ventilation is given as in the ordinary curing process. Space inside of the room is left along one side for stoves that supply the heat, and the tent is filled with boxes of fruit as in ordinary curing. The great disadvantage of the open-air tent for forced curing is that on account of the stove being in the same enclosure as the fruit, there is an unequal distribution of heat and gases from the stove, and, as a result, the coloring of the fruit is likely to be unequal. There are advantages, however, in that the rooms can be used for the regular curing of lemons or for storage purposes, when not needed for forced curing. During the sweating season many of the tents in the packing house are empty and if the regular tents are used for forced curing a large number of boxes can be done at one time.

45. As the sweating of lemons is now a well-established practice, most of the packing-house managers have had separate sweat rooms constructed for this purpose, either in the interior of the packing house or in separate buildings. In most instances these rooms have a basement under them in which the fires are kept. The floor of the sweat room is made of slatted planks 1 inch apart. The heat and products of combustion arise through these openings in the floor. The lower boxes usually get a little hotter than those above them, but not enough to do harm. To prevent those boxes immediately over the fires from becoming excessively hot, pieces of sheet iron are nailed to the joists of the floor.

46. Packers have done much experimenting trying to find what is the best source of heat to use when sweating lemons. Oil, gasoline, gas, and wood stoves, and steam have been tried, but the ordinary coal-oil stove burning either kerosene or distillate oil has proved thus far to be the most practical. Most of these stoves are of the type used in kitchens, and are fitted with asbestos wicks. After much experimenting it was found that the oil stoves that produced a sharp pungent odor seemed more effective in coloring lemons than the improved stoves that give complete combustion and developed practically no characteristic pungent odor.

In many of the sweat rooms the sharp pungent odor becomes so pronounced that it is practically impossible for a person to stay in the rooms for more than a few minutes at a time.

The results of government experiments on the forced curing of lemons indicate that so long as these pungent gases are present in the sweat room, heat and humidity are of minor importance. In the sweating of lemons as practiced at present, these two factors seem to be necessary, but it is thought that later devices may be perfected, based on the results of these experiments, whereby the coloring can be done by certain gaseous products without the need of heat and humidity in the sweat room. As was stated previously, not very much is known about the principles involved in the methods of curing. The lemon packer does know, however, that if he provides heat

and humidity and there is present in the room the gaseous products of combustion, the fruit will color. Just what later developments will show about forced curing cannot be foretold.

47. What the exact percentage of humidity in a sweat room should be, in the methods followed at present, has not been definitely determined, but in most rooms where successful coloring occurs it runs about 90 to 95 per cent.—that is, the air is practically saturated with water. If the fruit is allowed to wilt for want of moisture in the air, it is very hard to color it properly, as the green color seems to become fixed in the cells and sweating does not cause it to change. Evaporation and transpiration of moisture from the fruit itself provide a certain amount of moisture, but usually it is necessary to supply moisture artificially. This is usually done by placing pans of water on the stoves and allowing the water to evaporate. By regulating the quantity and temperature of the water, the air can usually be kept at about saturation.

A serious defect of forced curing is the tendency of the stems of the fruit to become loose and drop off. This condition affects the appearance of the lemons and is not desirable. Just what causes the loss of stems is not understood. In this connection it is interesting to quote from the report of the experiments made by the government on this subject:

> The causes leading to the loss of the stems from lemons during the sweating process are not well understood and a number of explanations have been offered. The most generally accepted explanation is that the stems are loosened by the excessive humidity in the sweat room. Much evidence may be found in support of this theory. The stems, as they break loose from the lemons, have the appearance of having been forced loose by the swelling of the pulpy tissues at the base of the stem through excessive absorption of water. As the heat and humidity of the sweat room are so radically different from that in the tents, it has seemed natural to assume that either one or both of these factors are instrumental in causing the stem to loosen. Furthermore, whenever fruit in tent curing undergoes a sweat the stems are liable to be lost. In such cases considerable quantities of moisture are often found to have accumulated on the lemons, and this condition may be assumed to have a causal relation to the loss of stems.
>
> In view of such evidence as has come to the writer's attention, other factors besides humidity seem to influence this result. The loss of stems seems to be greatest in cases where the fruit colors rapidly. In lots

requiring from 10 days to 2 weeks to produce the desired color, the dropping of the stems is considerably less than when the coloring takes place more rapidly, even though the conditions of temperature and humidity in the two sets of conditions seem to be approximately alike. It is observed that as long as the lemons remain green there are no signs of the loosening of the stems, but when the change of color begins to take place, especially if this happens rapidly, the loosening begins to be noticeable. This would seem to indicate that other factors than those mentioned play a rôle in this matter.

In order to obtain more information as to the cause of the loss of stems, a number of experiments were made, having for their object the determination of the part played by humidity and the nature of other possible influences. It was considered feasible to combine this work with the experiments on coloring which have already been described. * * * *.

The results of the experiments conducted seem to show that other factors than humidity play an important part in the loss of stems. They not only indicate clearly that an elimination of humidity will not prevent the stems from loosening, but they show equally well that if those factors which color fruit rapidly are withheld, the continued application of heat and humidity will not necessarily cause the stems to loosen. Thus they indicate a striking relationship between the coloring of the lemons and the loss of stems. The rapidity of the former change to a considerable degree measures the extent of the latter. This view is corroborated by practical observations in operating sweat rooms.

It must not be understood that humidity has no influence whatever in this matter. There is little doubt that excessive moisture has a tendency to remove the stems, at least under certain conditions. It is equally certain, however, that humidity is not the controlling factor in this problem and that to remedy the situation changes are required which must extend farther than a simple manipulation of the humidity. Indeed, from the apparently close connection between the coloring of the lemons and the loss of stems the finding of a way to save the stems without sacrificing time in coloring seems likely to be difficult.

48. Packing of Lemons.—After the fruit comes from the curing room, it is graded as to quality. The grades are much the same as for oranges, and are determined by the same conditions. Less machinery is used in the handling of lemons than of oranges. The lemons are graded by hand and are placed in trays that are carried to the packers. The fruit in the trays is not sorted to size; the sizing is done by the packer, who, on receiving a tray and deciding which size shall be packed in the box at hand, picks from the tray lemons that are of the right size. The next box is filled in the same manner, and if

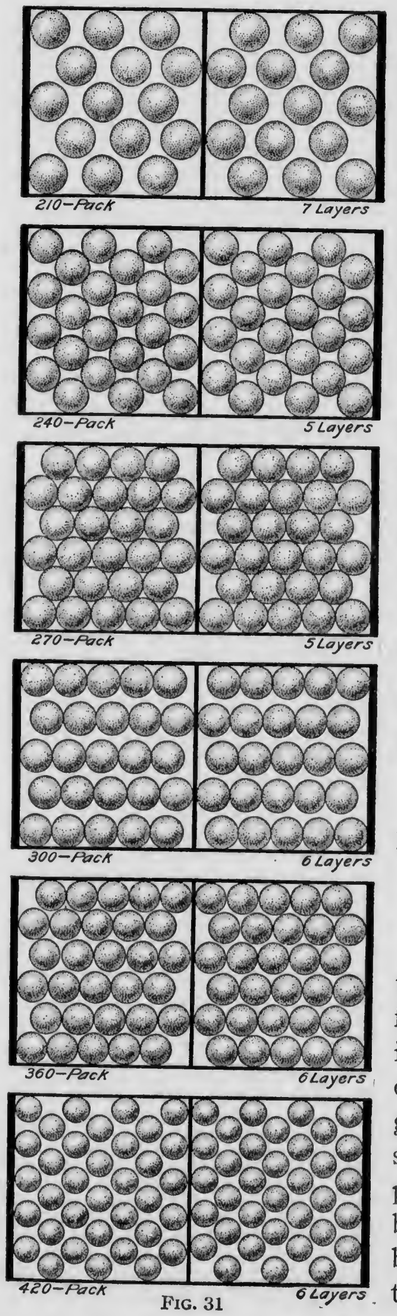


FIG. 31

there are not enough lemons of the desired size in the tray it is moved back a short distance, and the fruit picked from another tray that is near at hand. The arrangement in the boxes is similar to that of oranges. Fig. 31 shows the arrangement of the bottom layer, the number of fruits in the box, and the number of layers of the lemon packs.

The standard lemon boxes are $10\frac{1}{2}$ in.$\times$14 in.$\times$27 in., outside measurements, and are divided into two compartments, the same as orange boxes. Printed tissue paper is used for wrappers and lithographed labels that denote the brand and quality are pasted on the ends of the boxes in the manner practiced for oranges.

PACKING OF GRAPEFRUIT, LIMES, AND CITRONS

49. Grapefruit is packed in the same way as oranges. The fruit, being round, can be sized in the same way as is done with oranges. In the West, since grapefruit is not grown extensively and there is not much to pack, the sizing is usually done by hand. The regular orange box is used as a package, and the fruit is arranged in layers.

On account of the larger size of the grapefruit, there are fewer to the box, and, also, there are fewer packs used. Fig. 32 shows the arrangement of the bottom layer, and gives the number of layers and the number in the box for each pack.

Limes, what few are shipped, are packed the same as lemons. They are packed in lemon boxes and a few packages are usually included along with a carload of lemons. The Mexican sour limes, which are imported from Southern Mexico and sold in considerable quantities in the markets of the Pacific Coast, in the same way that the West Indian limes are sold in the East, are packed loosely in large boxes without any wrappings; the boxes contain about 2 bushels each. The packing is very crude, but the limes arrive in fairly good condition.

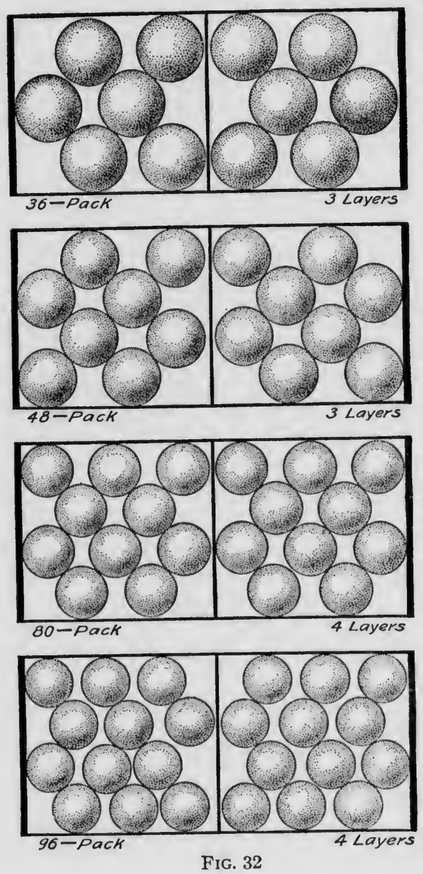


FIG. 32

50. Citrons, as was said before, are grown in a very limited quantity in California, and, for this reason, there have been no packages standardized for their shipment. The fruit is processed, which consists in cutting the fruits in half, scooping out the seeds and pulp, and boiling the thick rinds in a series of brines. Finally, sugar is introduced gradually until the fruit is candied. Each half is wrapped in white tissue paper and they are then packed snugly in rolls in plain wooden boxes holding about 20 pounds.

CITRUS FRUITS UNDER IRRIGATION

(PART 4)

CITRUS INJURIES AND PESTS

INJURY FROM COLD

1. Excessive cold during the winter months, when much of the citrus fruit is still hanging on the trees, is often responsible for loss in citrus groves. The cold injures both the fruit and the tender wood growth of the trees. Excessive cold in California may occur through a frost, or occasionally through a freeze. Frost and freeze must not be confounded. Frost usually occurs in restricted areas on clear, still nights; a freeze, on the contrary, usually follows or accompanies a storm. The effect is not local but general; in other words, the storm sweeps across great stretches of territory.

It may safely be said that few districts in the United States are entirely free from the effects of frost. Still, some localities are notoriously frosty; others may usually be considered entirely free, so far as damage to the trees, buds, or fruit is concerned. Yet even the places that are supposed to be free from frost may suffer sometimes. The conditions usually causing frost in California are as follows: A cold, dry northern wind blowing for several days displaces the air over a given area and substitutes cool, dry air for warm, moist air. When such a wind is followed by a calm clear night, the radiation of heat is very rapid, owing to the absence of the blanket of vapor in

the air. Objects at the surface of the earth lose heat by radiation and chill by contact the surrounding air. On calm nights this cold air, being heavier than warm air, flows down hill like water and fills up pockets, or depressions. The temperature is reduced in low areas to such an extent that frost occurs. On such a night there may be as much as 5 or 6 degrees difference in the temperature of the air at the top of a large orange tree and at the bottom near the ground.

Should a breeze spring up or any artificial air-currents be introduced that will set the air in motion and break up the blanket of cold air in these low depressions, the cold air will be diffused with the surrounding atmosphere and the temperature raised. In ordinary frosts only the lowlands are usually affected and the elevated areas or the foothills escape.

Occasionally, however, different conditions which are more serious prevail, as was the case during the disastrous freeze of January, 1913. At this time a very cold, dry, north wind blew for three days and crossed the protecting mountains. Radiation was carried to such a point that all the air was considerably below freezing, and as a result the trees and soil became very cold. In this case the highlands in most groves were affected worse than the lowlands, and it is the first record in California of what may be termed an inversion of temperature.

2. Effect of Frost on Vegetable Tissues.—The sap in the cells of a plant does not freeze but the low temperature of the atmosphere draws the water out of the cells, and this water forms ice crystals in the spaces between the cells. If this process continues long enough, the protoplasm of the cells may become so dried out that the tissues will die. At times, however, if the frost is of a short duration, the protoplasm may reabsorb the water from the ice when it melts and the cells will fully recover. In the case of every cell there is a certain limit of desiccation beyond which death of the tissue will result, and this limit is characteristic of the kind of plant. In the case of barley leaves it is very high; in orange, medium; in lemon, low; and in tomato, very low. This limit may vary, also, with the same plant according to whether it is in a state of

succulent growth or in a resting, or dormant, state. It will vary, also, according to the treatment the plant has received. For example, a gardener can harden off plants by subjecting them gradually to lower temperatures. The limit of desiccation will vary, too, according to the rate of thaw that follows the frost. If the water between the cells thaws out slowly, there will be less injury than if it thaws out rapidly. The individuality of the cells also influences the rate at which injury will occur. In any given block of tissue scattering cells only may die and collapse, and their places be taken up by the extra expansion of adjoining living cells.

In the case of citrus fruits, when a majority of the cells have passed the limit of desiccation, they do not reabsorb the water and it quickly evaporates through the skin of the fruit or may be drawn back through the stem and transpired through near-by leaves. A recently frozen orange in cross-section appears watery and soapy; later on it becomes dry. In some cases there may be a very bitter taste. Just what causes this bitter taste is not known, although many theories concerning the matter have been advanced. As far as is known, no injury whatever follows the eating of frozen citrus fruits.

The variety, also, has something to do with the susceptibility of citrus trees and fruit to injury from frost. Some varieties will often stand a temperature as low as 20° F. without much injury, and others will be injured by a temperature of 30° F. In the order of their resistance and the average temperature at which frost injury is likely to occur, citrus fruits rank as follows: (1) Satsuma, 20° F.; (2) Bahia and Valencia, 25° F.; (3) tangerines and pomelos, 25° F.; (4) lemons, 28° F.; (5) citrons, 29° F.; (6) limes, 30° F. The exact degree of cold any variety will stand is influenced, however, by the following conditions: (1) Degree of dormancy, (2) the state of the weather just preceding the freeze, (3) the length of time the cold lasts, and (4) the rapidity of subsequent thawing. If the tree is in a dormant state there is less likelihood of injury than if the tree is growing, because there will be less sap in the cells, and, hence, less water will form between the cells. If the weather has been relatively cold just before a frost, the tree will be somewhat

hardened to the effects of the frost, and, as a result, less injury will be done than if warm weather precedes a frost. When the cold weather lasts a long time there is more danger of the drying out of the protoplasm, and, therefore, there is more likelihood of injury than if it is of short duration. If there is a gradual thawing out of the water in the tissues, less injury will result than if the thawing out is rapid, because the cells have a better chance to adjust themselves and absorb the water from the melting ice crystals.

3. Influence of Stock on Scion.—It has been claimed from the results of experiments in Florida, that *Citrus trifoliata* stock will transmit its hardiness to the scion budded on it. However true this may be in Florida, it is not the case in California. Careful observations of the root-stock experiments of the University of California after the freeze of 1913 show no difference whatever in the injury to citrus trees grafted on different root stocks.

4. Methods of Protecting Groves.—Frost protection can be secured in several ways, which are: (1) by diminishing the radiation of heat, (2) by raising the dew point, (3) by heating the air artificially in order that the temperature may be raised.

5. The radiation of heat is diminished by interposing a screen of some sort to trap the heat rays given off. In Italy mats are spread over the tops of the trees. In California lath houses are used to protect seed-bed stock. Young trees are sometimes protected by covering them with burlap tents. Another method is to wrap them in corn stalks, tulle, or newspapers. These wrappings do not add any heat in themselves, but they act as efficient traps to prevent the radiation of heat which has been absorbed. Fig. 1 shows a young tree wrapped with corn stalks. The tops are left exposed, as the foliage will come out again after frost injury, provided the stalk is not badly injured.

6. The dew point can be raised by adding moisture to the air, since the latent heat of condensation at a temperature above

the danger point is made sensible. Much heat is required to vaporize water. Consequently, much heat is liberated when water vapor is condensed. It is said that in the condensation of one pint of dew or frost, as much heat is liberated in the air as would be required to raise 5 pints of water from the freezing to the boiling point. Thus, when the dew point is high the temperature is not apt to fall very low, because the large amount of heat liberated on condensation will act as a safety valve and retard the fall in temperature. When the dew point is low, however, the temperature may fall to a point where much injury is done before this safety valve gets into action. The practice of burning wet straw in the prune orchards of Oregon and peach orchards of Colorado at blossoming time is based on this principle. In California, however, straw is worth too much as a source of humus in the soil to be burned, and also, when the wind blows, which it often does during the mid-winter freezes, it would quickly blow this moist air away and replace it with dry air. Running irrigation water in the grove during a freeze also adds moisture to the air and is often a help in the protection of a grove. The spraying of a grove by means of any overhead irrigation system is also a means of protection that is used where groves are equipped with an overhead irrigation system.

FIG. 1

7. The air in the grove has in the past been heated artificially in a number of different ways, among which may be mentioned

steam pipes in the grove, electric heaters suspended by wires in each tree, the burning of briquets made of sawdust and crude oil, the burning of sacks of fuel, the burning of fuel in sheet-iron stoves, the burning of coal in wire baskets suspended on tripods, and the burning of oil in sheet-iron pots.

Only two of these methods of heating are in extensive use today, namely, the burning of coal in wire baskets suspended on tripods and the burning of oil in oil heaters. Of these two methods, the latter is by far the most largely used. A few growers still burn coal in wire baskets, because it is claimed for the coal that heat is obtained without a large amount of soot being produced. Soot is produced in abundance when oil is burned, and this results in smutting of the fruit. Notwithstanding the smutting of the fruit that is likely to occur when oil is used as fuel, it is conceded by the great majority of those interested in the heating of groves that the best and most practicable method is the burning of oil in some form of sheet-iron receptacle especially made for the purpose, since the labor and expense is not so great as where coal is burned in wire baskets.

8. Heating the Air With Oil Heaters.—Many makes of heaters are on the market, and new ones are being designed each year. Some of them are very satisfactory, and others are not so satisfactory. At present there are no reliable comparative figures on the efficiency of the different heaters on the market. Efficient oil heaters should possess the following characteristics: (1) They should hold oil enough to burn all night without refilling. (2) They should be capable of regulation, so that a low fire or a high fire can be burned; the regulation should be such that 1 gallon of oil is burned in 3 hours, or 1 gallon burned in 1 hour, as desired. (3) The pot should be capable of burning oils that are heavy in asphaltum; the reason for this is explained later. (4) The heater should be made of heavy material; this lessens the liability of warping, and such a pot will stand more wear than one of light material. (5) Some arrangement for keeping out the rain should be on the heater. (6) There should be a gauge indicating the highest level for

filling the vessel; this prevents spilling of oil, which is not only wasteful, but may result in damage to the trees if the oil ignites. (7) They should burn with good combustion, and make but little smoke. (8) They should be easy to fill, light, and extinguish, and not likely to explode. (9) The parts should nest for storage.

Not all of these advantages are found in all of the heaters offered for sale, but a grower, when purchasing a supply, should strive to get heaters that embody as many of these points as it is possible to find. Often he will be able to get valuable information from the experience of his neighbors about the merits of the different heaters found on the market. In Fig. 2 is shown a type of heater used in many California groves. It is a sheet-iron receptacle with a lid and a damper at the side to provide a draft. When a fire is to be lighted the lid is removed as shown in the illustration; the lid is replaced when it is desired to smother the blaze.

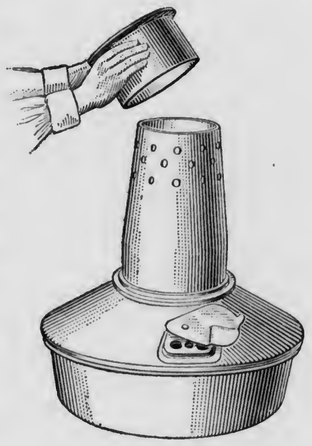


FIG. 2

9. The oil used in the West for heaters is known as fuel oil, which is crude oil from which some of the lighter oils, such as gasoline and kerosene, have been distilled. There are several grades of fuel oil on the market. The grower should ascertain which brands have given the best results in his vicinity and make his purchase accordingly.

Fuel oils are generally heavy in asphaltum and also contain some water. The water gets into the product from the pipes through which the oil is pumped from the wells. In order to pump this heavy oil, a thin sheet, or jacket, of water is forced in next the pipe to reduce the friction, and some of this water remains suspended in the oil. There are several disadvantages in the use of oil that has a large percentage of water and asphaltum in it. The presence of much water in the oil used in heaters will cause them to boil over as the heat changes the water to steam. Another difficulty in the use of these heavy oils is that

the asphaltum and other heavy substances that will not burn readily are left in the pot in the form of a residue, with the result that, after several burnings, the heaters hold less oil than at first. This deposition of residue is, to a certain extent, the fault of the heater, also, since some heaters will burn more of the asphaltum than others. Both the grade of oil and the heater should be carefully considered when heating equipment is purchased.

The fire in most types of heaters is extinguished by placing the covers on the pots, thus smothering the flame. Much trouble is experienced with some forms of heaters that are not tightly constructed. In these the supply of air cannot be entirely shut off, and as a result they may smolder for a time and then explode, scattering burning oil over the near-by trees and the men as well, if they happen to be near.

10. A grower should provide tanks in which to store the oil, in order that he may be ready to heat the grove at any time occasion demands. The capacity of the tanks should be sufficient to provide at least 1,000 gallons for each acre of grove. It is well to place the tank on a side hill so it may be filled and emptied by gravity. A tank wagon of 400 or 500 gallons capacity is generally used for distributing the oil through an orchard. These are for sale in the citrus-producing regions. On account of the difficulty of getting a loaded tank wagon through the orchard when the ground is soft, some growers pipe the oil to outlets distributed throughout the orchard. This entails extra expense, but gives much better satisfaction, especially on sticky or soft soils.

11. The number of heaters to use per acre will depend on the location of the grove, on the variety of trees, and on their age, size, and shape. In general, with full-grown bearing trees, not less than one heater to the tree, with a double extra row around the windward side of the orchard, should be provided. This means on an average 90 heaters per acre. Many small fires are better than a few large ones, as large ones tend to cause strong upward drafts instead of a steady side radiation.

The heaters should have a capacity of at least 3 gallons, and preferably 5 or even 7 gallons. Frost may occur on three or

four successive nights, and with the number of men and teams available it may be impossible to refill all the heaters during one day, especially when all the men have been out firing all the previous night. The heaters are placed equidistant from

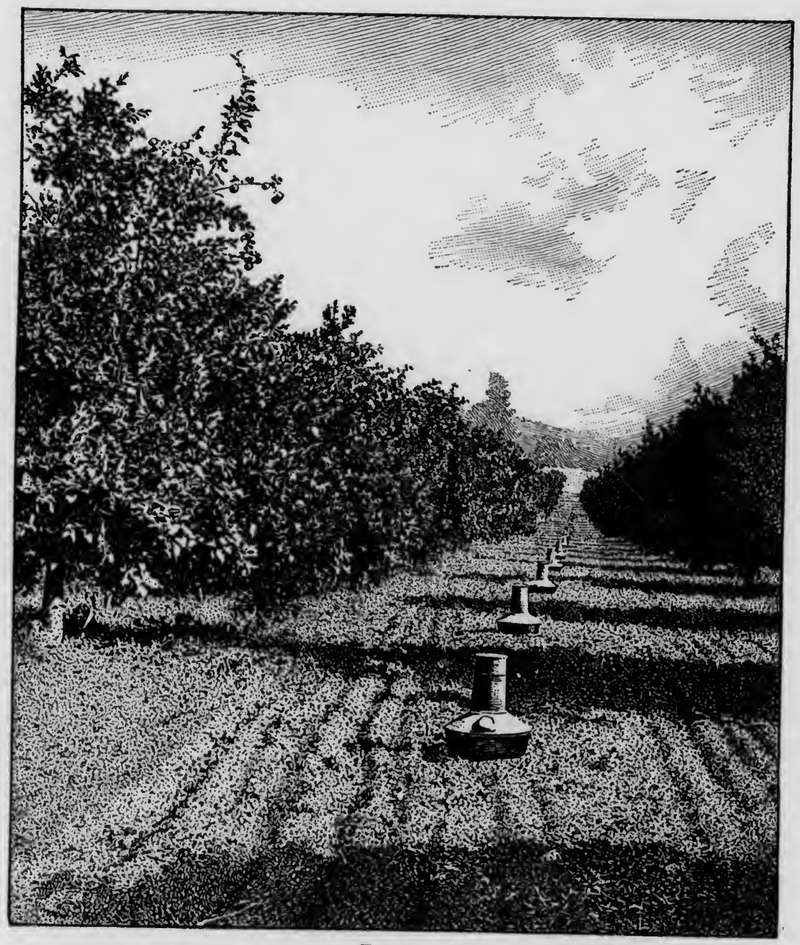


FIG. 3

the trees, but in line with one tree row in order that the wagons may be driven one way through the orchard. In Fig. 3 heaters in place in a grove are illustrated. It is never advisable to place the heaters directly under the foliage of citrus trees, on account of the danger of injury by fire.

12. The heaters should be kept filled and in place ready for lighting during the winter. The usual procedure when filling the heaters is for a gang of men to pass through the grove and remove the covers. These men are followed by the tank wagon and four or five men who fill the heaters. The oil is carried from the tank to the heaters in large pails, or 5-gallon tin oil cans from which the tops have been removed. A rope bale generally serves as a handle. As a rule, the grove is divided into areas with roadways along the sides or ends. When this is the case, the tank wagon is driven along the roadway, and each filler takes a row and fills the heaters for about half the length of the row. The tank wagon is then driven to the opposite side, and the other half of the heaters filled. The men who have removed the covers then follow the fillers and replace the covers. These covers are left in place until it is necessary to light the fires.

Firing should begin promptly when the leaves near the ground begin to freeze, which is determined by holding a leaf between the observer and the lantern. When frozen, the leaves will show transparent areas. In general, ice begins to form in the leaves at about 28° F.

Each man takes a row of heaters and lights them as fast as he can walk along and pull the covers off. Firing should begin at the coldest places, and if conditions of the weather change, and it becomes warmer, as it often does, the fires may be put out and all the men can go back to bed within an hour or two. If the cold increases, the other fires farther away from the coldest areas are lighted.

13. For igniting the oil in the heaters, various forms of lighters are used. In Fig. 4 is shown the Adamson torch, an appliance that has been found by experience to be very satisfactory. It is made in gallon and half-gallon sizes. Engine distillate oil is used as fuel. The cans are filled and the wicks at the ends of the snout lighted. When it is desired to start a heater the torch is tipped as shown in the illustration. Oil will then flow through the fire of the wick and become ignited, and drop into oil of the heater and cause it to ignite. Where lighters

are not available, growers often make a practice of throwing a small quantity of gasoline on the oil in the heater, and then ignite this gasoline with a burning torch of waste that has been soaked in oil; this is rather dangerous and is no work for children and it is really too hazardous to be recommended.

Should it be necessary to refill small-capacity heaters before they are entirely burned out, the cover is placed for a minute or two over the fire until the flame is completely extinguished, when it may be removed and the oil poured in.

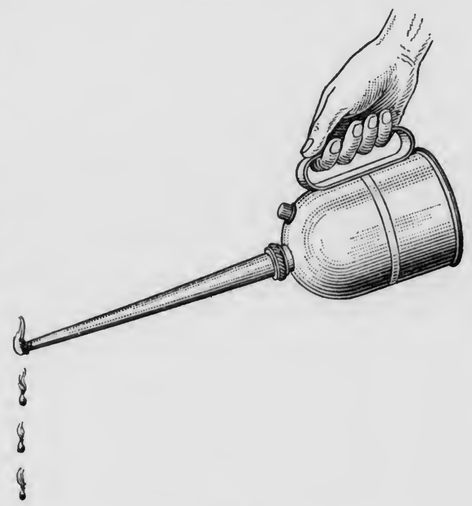


FIG. 4

14. It is a good plan to provide an automatic alarm thermometer as a means of awakening the grower when a frost occurs. There are many good types on the market, but all of them, when placed in a grove, should be tested often and should not be relied on entirely. If the indications are for freezing temperatures, it is well to stay up and watch the temperature and not rely absolutely on the alarm thermometer. The alarm thermometers are an aid, however, and often have been the means of getting men up in time to save groves. The thermometer should be placed in the coldest spot in the grove and the bells, which ring when the temperature has reached a certain point, should be screwed to the wall in the sleeping room of the person responsible for lighting the fires. The alarm is usually set at 30° F. for lemons and 27° F. for oranges. The best plan is to light the fires when the leaves begin to turn transparent, as described previously. It is a mistake to defer lighting in the hope of overcoming the cold later in the night, for experience has shown that this is a very difficult thing to do.

15. In some localities the growers have formed cooperative organizations which buy the heaters and oil wholesale and employ motorcycle squads to patrol the district and telephone in temperatures to headquarters. The manager orders the previously organized frost fighters to that part of the area which according to his information needs protection from the frost. The grower is awakened by the motorcycle men at the proper time, furnished up-to-the-minute information from the weather bureau and a group of men is assigned to attend to his fires. Such an organization adds much to the safety and peace of mind of its members.

It should be remembered that orchard heating may pay even though the fruit is lost, for the heat may save the fruiting wood from freezing and it will thus be able to bear a full crop the next year, whereas, if no firing is done, it may take the trees 2 or 3 years to recuperate.

16. Cost of Equipment and Heating.—The cost of heating a grove will, of course, vary with the kind of equipment, the length of time the heaters must be used each night of the freeze, and the method of handling the work. Each ranch would have a different total expenditure to quote from a typical case. Richardson Brothers give the following as the cost of equipment, oil, and labor for sixteen nights of heating during the freeze of 1912–13:

EQUIPMENT		
500 Hamilton heaters (3 gallons)	$200.00	
700 Bolton heaters (2 gallons)	154.00	
Wagon tank for oil (463 gallons)	48.00	
Cement oil cistern (8,500 gallons)	125.00	
3 oil buckets and 2 lighters	6.25	
4 thermometers and alarm bells	40.00	
		$ 573.25
OIL AND LABOR		
Oil for 16 nights (16,195 gallons)	$437.26	
Labor bill for same time	201.50	
		$ 638.76
Total expense		$1,212.01

17. Disposition of Frozen Fruit.—For various periods up to 4 or 5 weeks after a freeze, frozen citrus fruits are just as good for consumption as sound fruit. The variation in time is due to different weather conditions, the fruit tending to dry out and become pithy more rapidly if a dry wind is blowing than if there is no such wind. The rumor that frosted citrus fruit is poisonous is entirely without foundation, for many carloads of such fruit have been consumed both in Florida and in California, and there is not a case on record of any harm resulting therefrom. After the fruit loses its juice and becomes dry it is, of course, worthless, and sometimes frozen oranges become bitter in flavor. On account of this worthless fruit sometimes being sent to market, the Board of Food and Drug Inspection of the United States Department of Agriculture has made the following ruling in regard to frozen citrus fruit: "Citrus fruit will be deemed adulterated within the meaning of the Food and Drugs Act, if the contents of any package found in interstate commerce contain 15 per cent. or more of citrus fruit, which, on a transverse section through the center, shows a marked drying in 20 per cent. or more of the exposed pulp."

There is much variation in the degree of frosting of fruit on the same tree. The oranges on the tops of the tall trees are usually less frozen than those near the ground, and oranges on the inside of the tree are less frozen than those on the outside. Thus, when the fruit is picked after a damaging freeze the good and bad fruit will be mixed together. If the grower does not wish to sell all his fruit at a great discount as frozen fruit, he must separate the frozen from the sound fruit. All methods of separation are based on the principle that frosted fruit loses its juice and becomes lighter. In mechanical separation the fruit is placed in a liquid having a certain specific gravity. The frozen fruit, being lighter, will come to the surface, and the sound fruit, being heavier, will sink. Formerly, a mixture of kerosene and refinery residuum oils mixed to the specific gravity of 82 was used as the liquid, but as the oil left a taint on the fruit, the process has been discontinued. Then for several years denatured alcohol was used with good results.

This method is expensive, on account of the cost of the alcohol, but it is still used for lemons. The alcohol is used at a specific gravity of about 82, and a special machine is employed in the process. An endless belt which carries paddles passes across the surface of the liquid and sweeps the floating fruit off to one chute and returns dragging on the bottom and forces the sound fruit out of another chute at the opposite end of the machine. The cost of separating fruit with alcohol is about 7 cents a box.

In 1913 a new machine was invented for separating frosted fruit from sound fruit. The machine uses pure water and this process is far cheaper and more satisfactory than any other process. In this process water is kept flowing from one end of a long trough to the other and back through a pipe at a given rate of speed by a motor-driven propeller in the return pipe. The oranges are conveyed to a point above the water near one end and dropped into the swiftly moving current. The sound oranges, being heavy, sink to a greater depth than the unsound ones and are carried by the current under a woven-wire screen, which is placed horizontally 12 inches or more below the surface of the water at one end of the machine. The frozen fruit, being light, bobs up quickly and passes above the screen by the time the current carries it there. Each class is then delivered by separate belts into their respective bins. The screen may be adjusted to any percentage of separation desired or to suit different lots of fruit simply by raising or lowering it.

The only objection to this machine is that it separates too well. Oranges that happen to be light from such causes as open centers, thick skins, etc., will be passed out with the frozen fruit. This, however, is, in a way, an advantage for the consumer, because it improves the grade of the sound fruit. The cost of building such a machine is about $250 for the size that will fill 1,200 boxes a day, and the cost of separating the fruit is about ½ cent a box.

This type of machine is not used for lemons, because the fruit not being round, the depth to which they will sink in the water will not depend so much on whether they are frozen or not as on whether they strike the water on end or on the

side. As stated previously, the alcohol method is still used for lemons.

18. Treatment of Smutted Fruit.—The greatest objection to heating orchards with oil heaters is that the smoke becomes very thick and often does considerable damage to the interior furnishings of homes. The soot also collects on the trees and fruit. No injury results from the sooting of the trees, but sooted fruit must be cleaned before it is sent to market. The soot is greasy, gets into the pits in the skin between the oil cells and is very difficult to remove without injuring the rind, thus causing decay in transit. A great deal of experimenting has been done in solving this important problem. A method now quite generally used is to dip the fruit in water on the surface of which an inch of kerosene is floating. Two men lower a box of fruit into this tank and then raise it slowly, allowing a film of kerosene to remain on the fruit. The box of fruit drains for about a minute, during which the kerosene cuts the soot. The fruit is then quickly run through a brush-type washing machine containing water heated by steam pipes to a temperature of exactly 110° F. The temperature is never allowed to vary from this. The wash water contains 30 pounds of Gold Dust washing powder per 800 gallons of water, and about 3 pounds more of this washing powder is added during each hour the machine is in operation, as more water is added to make up for what is removed by wet fruit. By this cleaning process fruits that are wind-bruised, thorn-stabbed, or otherwise abraded are somewhat browned and disfigured, but sound fruit is not injured.

19. Disposition of Frosted Culls.—In a few sections of California are located factories in which oil of lemon, oil of orange, citrate of magnesia, citrate of lime, citric acid, etc., are manufactured from citrus fruit. Frozen fruit has been found satisfactory for the manufacture of these products, and, therefore, if a factory is near or transportation charges to one are not too excessive, a grower can sometimes dispose of his frozen fruit to advantage at these factories.

In the absence of such factories to extract the by-products,

often there are thousands of tons of culls that have to be thrown away. These should be spread back on the land for their fertilizing and humus value. There seems to be no danger whatever in California of making the soil acid by spreading citrus fruits on the ground. Culls have been applied to soil to a depth of 6 inches once each year for several years and gradually cultivated into the soil with no ill effects. There has been an improvement in the trees instead.

20. Care of Grove After a Freeze.—Freezing, if severe enough, may cause the splitting of the bark on the trunks of young trees and kill tender branches and twigs on trees of all ages. When the bark splits, many growers advocate binding the trunk with waxed tape, or covering the exposed parts with grafting wax or other such materials. Others contend that if the bark is split and loosened it can never be restored to active service. It seems, however, that whether the split bark can be restored to active service or not, it is well temporarily to cover the wound with some wound dressing for the purpose of preventing excessive drying of the inner tissues, and after it is apparent how deep the injury extends to cut back to healthy bark and allow the tree to heal the wound.

Since freezing destroys some of the foliage and tender branches, it is a good plan, after a killing frost, to prune the roots commensurate with the loss of top. For this reason a deep plowing of the soil, even subsoil plowing, is advisable. This will break off many feeding roots, with the result that roots and tops of the trees will be better balanced than if no such plowing were done.

INJURIES CAUSED BY WIND

21. Much damage is done in orange groves by excessive winds that scar the fruit, break the limbs, and remove numerous leaves and tender twigs. The extent of injury from this source depends largely on the location of the grove and on the pruning that is given to the trees. If groves are located in positions sheltered from prevailing winds, the injury from this source will be comparatively slight. Not all fruit growers

can locate in such sheltered positions, and consequently some artificial shelter must be resorted to if protection is desired. Practically all artificial shelters are in the nature of a windbreak planted on the windward side of the grove. In Southern California, the Eucalyptus, or blue-gum tree, which is a tall-growing tree, and some low-growing tree, such as the Monterey cypress or the pepper tree, planted alternately, are much used as windbreaks. In some cases the pepper trees are planted alone. Near the coast, however, pepper trees are so seriously affected with black scale that it is unwise to use them as windbreaks. In Central and Northern California, the Monterey pine and a native white cedar are much used for windbreaks. All of these trees, being evergreens, form a wind barrier in winter as well as in summer. There are many arguments against the use of windbreaks. The chief one is that it is usually necessary to give up one row of grove trees, and this some growers feel will not pay them. Also, windbreaks often harbor diseases and scale insects, which make them undesirable around a grove. There are cases on record, however, where the removal of a windbreak has resulted in losses greater than would have been incurred by retaining the trees.

Sometimes, too, great damage is due to faulty pruning. If the trees are so pruned that the branches do not rub and chafe each other and the long leaders so headed in that they cannot whip around and bruise the fruit, artificial windbreaks sometimes will be unnecessary.

INJURIES FROM RODENTS

22. Ground squirrels, in some citrus sections of the West, damage young trees by peeling the bark near the base. In extreme cases they may even girdle the trees and cause their death if the damage is not repaired. These rodents are more likely to be prevalent in newly planted sections or along the edges of groves rather than in the interior of the groves. They do not make holes in the grove on account of the presence of irrigation water in the soil. They lie in holes in dry banks at a distance from the grove and are only troublesome to the citrus

trees during the dry seasons after the grass and other plants have dried up.

Protection from these rodents can be secured in two ways: (1) by protecting the bark with some material; and (2) by destroying them, either by means of poisoned grain or by the liberation of carbon bisulphide in their burrows.

The most satisfactory method of protection is to wrap ordinary house screen around the base of the tree. The yucca protectors used for placing around young trees to shield them from the direct rays of the sun and the corn stalks used to prevent frost injury to the trunks also act to some extent as protection from ground squirrels. This method, while it protects the trees, does not kill the squirrels. If it is desired on the other hand to kill the squirrels, some kind of poison is used. The poisoned-grain method is generally used during the dry season, and the carbon-bisulphide treatment during the rainy season, when there is enough moisture in the soil to prevent the general diffusion of the gas beyond the open burrows.

23. A good method of preparing and using poisoned grain is as follows: Dissolve $\frac{1}{8}$ teacupful of ordinary laundry starch in a little cold water, add about $\frac{3}{8}$ pint of boiling water and stir. This will make a thick solution. While hot, add $\frac{1}{4}$ ounce of ground or powdered strychnine sulphate and mix until free from lumps; then add $\frac{1}{4}$ teaspoonful saccharine, and beat thoroughly. Pour this solution over 5 quarts of clean barley and stir rapidly until the poison is evenly distributed over the grain, and then allow the grain to dry. This poisoned grain, if properly prepared, will keep almost indefinitely, and as the poison is in a coating on the outside of the barley, it will act more quickly than if the grain were soaked in poison. This quantity is ample for 10 or 15 acres, and it can be prepared for about $1.

The poison is applied by scattering it in places frequented by the squirrels, and, as stated, is generally used during the dry season. A good time to combat squirrels is the last of March or the first of April, which is the breeding season for the animals. One killed at this time may be equivalent to eight or nine killed later in the season. The poisoning by this method should

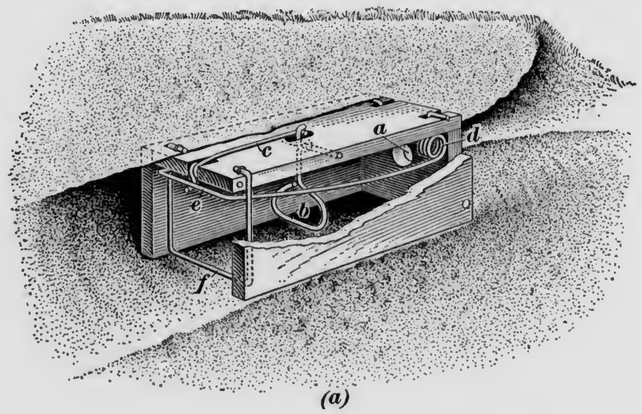
continue, however, during the summer and fall. Obviously, all poultry should be kept out of the groves if the squirrels are being poisoned by this method.

24. When carbon bisulphide is used, pour about $1\frac{1}{2}$ fluid ounces of the liquid on a small ball of cotton waste or a piece of burlap, and place the waste or cloth as far down in the burrow as possible and then tramp dirt over the opening. The gas coming from the liquid will flow down into the burrow and kill the squirrels. Machines known as squirrel destructors that have been devised by the United States public health service are on the market. With one of these machines carbon bisulphide is injected into the burrow, and then the opening is closed. The gas will diffuse in the burrow and kill the animal. These machines are more applicable where large numbers of squirrels are to be killed, such as in grain fields, than where only a few must be combated, as in citrus groves.

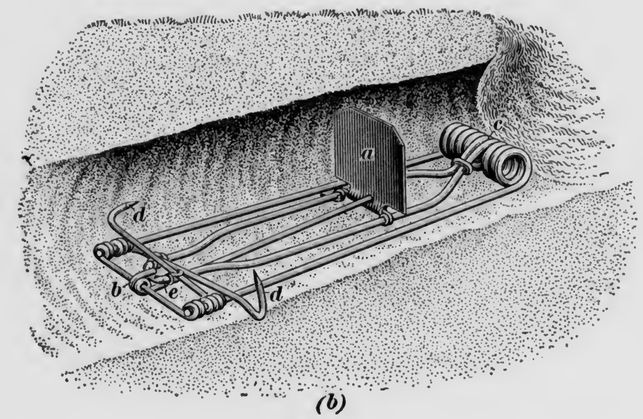
To prevent the evaporation of the carbon bisulphide from the vessel in which it is contained, enough water should be poured into the vessel to cover the bisulphide, which, being heavier than water, will stay below it in the vessel and will not evaporate. The liquid should be kept from fires, since heat causes it to explode.

25. Pocket gophers, when they get into a grove, are likely to work considerable damage unless exterminated. They work from one tree to another, chewing the bark from one side of a root up to the trunk of the tree. A root thus injured soon dies and rots. The gophers are kept in control by means of traps and poisons. In Fig. 5 is shown two styles of traps used in California. When setting the box trap shown in (*a*), a mound of earth is dug into until the burrow is found, then the trap is set on the slanting floor of the burrow with the end containing the hole *a* uppermost. Earth is then filled into the burrow, leaving only the hole *a* exposed to the light. The gopher in coming toward the light to close the burrow, which is a habit of the animals, will pass into the trap and touch the trigger *b*. This releases *c* and causes the spring *d* to push the wire portion *e* down on the wire portion *f*, and thus kills the gopher. The

wire trap is set on the floor of a burrow as shown in (*b*); *a* is a flat piece of metal that holds the trigger *b* in place; *c* is a spring with tension upwards; *d*, *d* are sharp wire hooks that are forced around the body of the gopher; *e* is a rounded end of wire to which the trigger is hooked when the trap is set. With the



(*a*)



(*b*)

FIG. 5

trap set in a burrow a gopher on coming to the surface will touch the flat piece *a* with his head. This causes the trap to be sprung and as the gopher is directly over the trap the wire hooks *d* will be forced around and into its body.

Gophers are sometimes killed by the use of poisoned barley or a raisin in which a flake of strychnine sulphate has been placed.

One method is to place the poison in the burrow with a long-handled spoon; another is to shove a sharp, rounded stick into the ground near the mound made by the gopher until it strikes the burrow, and then after withdrawing the stick drop in the poison. The hole should be closed with grass and the mound leveled. If a new mound is formed near by, the gopher was not killed and the dose of poison should be repeated.

INSECT PESTS

INTRODUCTION

26. One of the most important factors with which the citrus-fruit grower has to contend is the control of insect and allied pests that do damage to the trees and fruit. Among the principal insect pests of California are the black scale, the red or orange scale, the yellow scale, the purple scale, the cottony cushion scale, the soft brown scale, the hemispherical scale, the greedy scale, the citrus mealy bug, the red spiders and mites, the thrips, the aphids, the orange tortrix, Fuller's rose beetle, and the Diabrotica soror. Two serious pests not introduced thus far in California, but on which all growers should wage war, are the orange maggot and the citrus white fly.

Not all of these pests are found in all parts of the state. In regard to this matter, it is interesting to note the following statement by H. J. Quayle, entomologist at the University of California:

"General climatic differences appear to account for the differences in the insect pests, not only of the northern and southern sections, but also within the latter section itself, since even here there is a wide range of variation. However, it is not safe to speak too confidently of the influence of climate on insect distribution. Time has changed a number of ideas to correspond with the facts as they exist today. It had been asserted that California need have no fear of the citrus white fly, yet this pest got a fairly good foothold in a part of the state least suited to it, according to theory. It was also

held that the black scale would not exist in the Riverside section, yet it occurs there and attacks citrus trees. Likewise, the purple scale was supposed not to become a pest in arid California, and, if it did become established, it would be limited to a narrower range than its distribution at the present time indicates.

"In general, however, it may be said that the black scale thrives best in sections near the coast, as shown by its prevalence in the citrus belt from Santa Barbara to San Diego, and also on deciduous trees in the coast counties of the north. The interior valley citrus sections are not troubled with the black scale, though it may occur there on such plants as the olive and oleander. The purple scale, thus far, is limited to the coast counties, occurring with the black, but not of such wide distribution. The red and yellow scales occur both near the coast and in the interior, though they are considered the more typical scales of the warmer interior sections.

"Aside from the scale insects mentioned, the next most general citrus tree pests are to be found among the spiders and mites. The Florida red spider and the six-spotted mite are widely distributed, while the silver mite of the lemon is restricted to a limited section in San Diego County. The mealy bug has become a rather serious pest in certain limited sections in Ventura and San Diego counties, and also smaller infestations in other counties. The soft brown, cottony cushion, and a few other scales sometimes occur in considerable numbers over small areas, but are not usually considered permanent pests. A species of thrips has recently come into prominence as a pest in the San Joaquin section. The orange tortrix is the only insect that burrows into the orange itself to any extent, and this fortunately has not become a very important pest thus far. Other insects which attack the fruit occasionally are grasshoppers, katydids, and cutworms. Other biting insects attacking the leaves only are Fuller's rose beetle and the common Diabrotica.

"A couple of dozen species will thus cover all the insects of economic importance attacking citrus trees in California and, of these, practically all of the control work is directed against

but four of the scale insects, the black, the red, the yellow, and the purple."

An idea of the cost of controlling the insect pests of California can be gained from the following statement by Mr. Quayle:

"More than half a million dollars are expended annually in their control. This amount includes only what is actually expended in fumigation and spraying, and does not take into consideration the loss of fruit from improperly treated trees or trees not treated at all. * * * Furthermore, each county maintains a horticultural commissioner, and many of them a corps of inspectors, primarily on account of insect enemies, who are charged with the quarantine and inspection work, the cost of which in some of the counties may run as high as $25,000 annually. * * *

"It has been estimated that the average cost of fumigation per tree, taking the whole of the citrus belt, amounts to about 30 or 40 cents, which means an expense of approximately $30 to $40 per acre, and this is done on an average about every other year. This is intensive insect fighting, but when the improved market value of the fruit is considered, it is money judiciously spent with such a valuable crop as the orange or lemon."

27. In Arizona, citrus culture is of more recent introduction than in California, and, as a result, there are fewer kinds of insect pests to combat. There are, however, some pests found in the state, and growers and officials of the agricultural associations are making efforts to keep those already there under control and to prevent the importation of any new ones.

SCALE INSECTS

28. The most widely distributed insect pests in the citrus groves of the West are the scale insects. These are minute, soft-bodied insects with sucking mouth parts; they secrete a scale covering under which the true insect lives. The ordinary observer will observe the scale and nothing more, but if the scaly covering is removed and the interior examined with a lens the insect can readily be seen. For the reason that these

insects live under a scale, they are called scale insects, but in common usage the term insect has been dropped and the term scale is most frequently used. This sometimes causes confusion, especially when speaking of the adults of both sexes.

In the more specialized scale insects, the females are stationary in adult life; in other words, soon after the larvas are hatched from the eggs they settle down in one spot on twigs or leaves, insert their sucking mouth parts and remain there throughout their existence. Their bodies usually lack legs, eyes, antennæ, and wings. It is the female scale insect which has given rise to the term scale, because it is this scale that the grower ordinarily sees and fights. The flattish, nearly circular little red spots or the more ovate blackish spots that are frequently seen on carelessly packed oranges are scale insects and are excellent examples of the female insect. The male scale insects, during their earlier stages of development, also secrete a scaly covering and develop under this protection. They resemble closely the immature female scale insects, though they are usually smaller, and sometimes the scale covering is slightly different in shape. The adult male insects, however, unlike the female scale insects, at the last stage of development, emerge from under the scales as two-winged insects that have eyes, antennæ, and legs, but, strangely enough, have no mouth parts, nor mouth openings, so that they cannot take food during the adult period. Their period of life, therefore, during the adult stage, is of short duration, usually a few hours or days at most. They live long enough to fertilize the females and then die. The male scale insects are much more rarely seen than the females, and for this reason are relatively unimportant. In these Sections, when speaking of scale insects, the term scale will apply to the females unless the sex is otherwise designated. Also, the conditions described above will be considered typical unless otherwise designated.

29. Black Scale.—The black scale is about the most important insect pest in the citrus groves of the West. Its importance is due to the amount of control work directed against it and its wide distribution throughout the citrus fruit

belt. There are several other insects that are more difficult to control, such as mealy bugs and purple and red scales, but these pests are not so generally distributed as the black scale.

The black scale withdraws sap from the tree by feeding, yet this is not the principal injury to the tree. It is true that a certain amount of injury is done the smaller twigs, which sometimes die in the case of severe infestations, but, so far as the citrus fruits are concerned, the principal injury is due to the secretion of honeydew, which serves as a growth medium for sooty mold fungus. Large quantities of honeydew are excreted on the upper surfaces of the leaves and fruit. The fungus spreads over the trees in this honeydew, often completely coating the leaves. A coating of this kind over the leaves prevents the proper exchange of gases and shuts out the light, which tends to diminish the natural vigor of the tree. Light is necessary for the formation of starch and sugar, and consequently there may, in severe cases, be a great reduction in the sugar content of the fruit. Aside from the injuries mentioned, the greatest injury is due to the presence of the sooty mold on the fruit. The market demands clean oranges and lemons; therefore, before the fruits can be marketed, they must be washed, which adds to the cost of handling the product. In addition, in the washing process, the rind is apt to be injured, and into these abrasions the spores of blue mold and other fungi with which the wash water may be infected find their way and cause the decay of the fruit before it reaches the consumer.

FIG. 6

The scale of the adult female insect is approximately a hemisphere in shape; it is leathery and hard in texture. In Fig. 6 mature scales are shown magnified about twenty-five times.

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FIG. 6

The scale of the adult female insect is approximately a hemisphere in shape; it is leathery and hard in texture. In Fig. 6 mature scales are shown magnified about twenty-five times.

On the back of the mature scale, even from the time it is half-grown, there is a distinct letter H, which is the most prominent character that distinguishes it from other scale insects. The color varies from dark brown to jet black; this insect is darker than any other scale insect that infests the orange. The female is stationary and dies soon after the eggs have been deposited.

The male scale is much longer in proportion to its size and is narrower than the female scale when in the same stage of development, but the color is practically the same. It is an active, winged insect, when adult. The male flies about until it has fertilized the female and then dies. The males are not often seen, since they are relatively few as compared with the females. An idea of the appearance and size of the male can be gained from Fig. 7, which is a drawing of a black male scale insect magnified about twenty-five times.

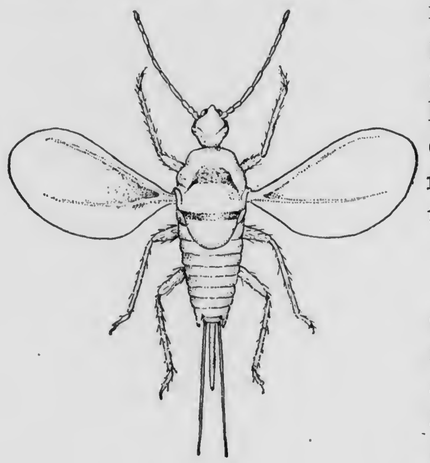


FIG. 7

30. The female deposits eggs beneath her body at the rate of twenty-five to forty a day until a total of from 300 to 3,000 eggs have been deposited; the average is from 1,500 to 2,000. The egg-laying period is from 6 weeks to 2 months. As eggs are deposited, the body gradually becomes hollow, so that when all the eggs are deposited the scale is simply a hollow hemisphere filled with eggs. The eggs are oval in shape and about $\frac{1}{80}$ inch in longitudinal diameter. When first deposited they are nearly white in color, but soon change to a pinkish cast and just before hatching become distinctly orange in color.

Not nearly all of the eggs deposited reach maturity. The black scale suffers its greatest mortality during the first 3 or 4 days when the young are active and during the molts. Weather,

diseases, and parasites all have an influence on retarding the number that reach maturity. In fact, it has been stated by a leading entomologist that the progeny maturing is approximately equal to the number of parents that gave them birth. Where methods of control are practiced the black scale should therefore be kept in check. Eggs of this insect may be found at any season of the year in some sections of Southern California, but the largest number occurs during May, June, and the first part of July. During the summer months the eggs hatch in from 16 to 21 days; during winter they hatch in from 4 to 6 weeks. On hatching, the young remain beneath the parent scale for 1 or 2 days. They then emerge and crawl about for 2 or 3 days, and then most of them settle on the leaves, some on the tender twigs, and a few on the older stems of the tree. Those insects that first settle on leaves and old corky branches, do not often come to maturity there; as they become partly grown they loosen their hold and migrate to the tender twigs and branches, the exact time varying greatly, but always before they are half grown. A drying of the leaf on which a scale is fixed will cause a migration before the first or second molt, but, as a rule, the greatest migration takes place after the second molt. Those insects that settle on the tender twigs at first, develop there and the females remain fixed in the same spot for life. Soon after the settling on the twigs or leaves, the young scales become flatter and somewhat larger in area. There is practically no difference between the sexes at this early stage of development.

31. The first molt occurs in from 4 to 6 weeks after birth during the summer months, and this period may be prolonged to 2 months or more during the winter season for the same stage of development in winter broods. The molting consists of a splitting of the old skin, which is pushed backwards until it is free from the insect. After the first molt, the first marked differences arise between the sexes. The male assumes a more elongated shape. It is light brown in color, and the eyes are visible in the latter part of the first molting stage, as small dark areas on the front margin. The female looks much the same as

before molting, except that during this stage the formation of the letter H begins on the scale. At this time the ridge that forms the bar of the letter extends from one end of the scale to the other.

Both the male and the female undergo a second molt which is somewhat different for each sex, about 4 to 6 weeks after the first molt. The male scale, after molting, grows rapidly until it is about five times the length when hatched. At the end of this stage a puparium is formed from secretions of the body surface. This is transparent and completely covers the insect. The propupal stage, which lasts about 8 days, follows the puparium stage, and following this is the pupal stage of about 10 days. From the pupal stage the adult emerges as a winged insect, which lives for about 3 days, during which time it fecundates the females. From hatching until maturity averages 3 months, which is about the time that females hatched at the same time have completed the second molt and are ready for fecundation.

The difference between the male and the female becomes more marked after the second molt, which brings the female to its adult stage as far as molting is concerned. The two ends of the ridge on the back of the scale developed after the first molt become obliterated and two cross-bars develop at right angles to this ridge, which shows on the scale as a well-defined letter H. At the same time there is a great increase in size and also in general form. The scale is no longer flattened and more or less elongate, but is round and greatly thickened. As egg laying begins, the scale takes on a smoother, leathery surface and also becomes darker in color.

Usually about 8 to 10 months are required to bring the female to the egg-laying stage. There appears, therefore, to be but one complete brood of black scales a year and the majority of the insects reach maturity in the spring months. Depending on seasons and locality, there is more or less overlapping of broods, so that in some sections the insects may be found in some of the stages at all seasons of the year. However, in other sections where the seasons are very pronounced, more scales come to maturity at a definite time.

32. The spread of the black scale is dependent largely on outside agencies rather than on its own means of locomotion. A few scales will make their way from one tree to the next and possibly to the second or the third tree in a grove, but, as a rule, they remain on the tree where the eggs were deposited. The wind aids the male insects in passing from one tree to another, but it does not have much effect on the spread of the females. The most important means of spreading this scale is by active insects that carry them from place to place. The ladybird beetles seem to be instrumental in carrying many of them. These beetles move about the scale-infested trees and feed on the insects, and many cases have been observed where young scales were carried on the backs of beetles. In one experiment in California where 100 ladybird beetles were confined for a day in a jar containing twigs infested with black scale, it was found that one beetle in every ten or fifteen carried from one to four scales. Naturally, in flying from tree to tree, these beetles spread many of these pests.

Birds also carry many of the small scales on their feet and in flying from tree to tree spread the insects to even greater distances than the beetles. Nursery stock, if infested, carries the insects from place to place. Rigid quarantine laws and fumigation of infested stock is necessary, therefore, to restrict their spread. Infested fruit is also a means of spreading the scale.

33. Several parasitic and predatory enemies serve to hold the black scale in check. The most important parasitic enemy is a fly-like insect, the *Scutellista cyanea*, which was introduced into California from South Africa by the United States Department of Agriculture, in 1900. This insect is generally spoken of as the Scutellista parasite. The eggs of the insect are deposited under the black scale during or a little previous to the deposition of the scale eggs. Several eggs may be deposited under one scale, apparently by different insects, but rarely not more than one or two parasites reach maturity, although three or even four have been known to mature. These eggs hatch in from 5 to 6 days into white, grublike larvas that feed on the contents of the eggs of the scale, or, if no eggs are present,

on the scale itself. On completing the larval growth the insects change to the pupal stage, and finally into the adult stage, when they emerge through holes that they eat in the scales.

The predacious enemies of the black scale are several species of the ladybird beetles. They attack the eggs and the young scales. The control of the black scale, aside from its natural enemies, which, as a rule, do not hold it in check, is accomplished by fumigation, as described later.

34. Red, or Orange, Scale.—A scale that ranks second to the black scale in importance is the red, or orange, scale. In many sections it is associated with the black scale but is

FIG. 8

often found beyond the range of the black scale. The red scale gives off no honeydew, differing from the black scale in this respect. The red scales may injure the tree in several ways. It may be that the insects check the growth of the tree by sucking the sap or it may be that the insects have the same effect on the citrus trees that the San José scale has on the apple. The San José scale on the apple and other deciduous fruits produces a pink discoloration. This discoloration is spoken of as a toxic effect. It may be that the red scale exerts the same influence on the citrus fruits without producing any discoloration on the trees or fruit. It is true that when the scale feeds on the leaves, a yellow spot results at the point

where the leaf is injured, but this is due to the loss of chlorophyll in the leaf rather than to any toxic effect on the leaf. Again, it might be said that interference with the exchange of gases by the scales covering the stomates of the leaves or a combination of all these causes has some effect on checking the growth of the tree. Whatever the nature of the injury, it is true that red scales infest all parts of the tree and are much more virulent

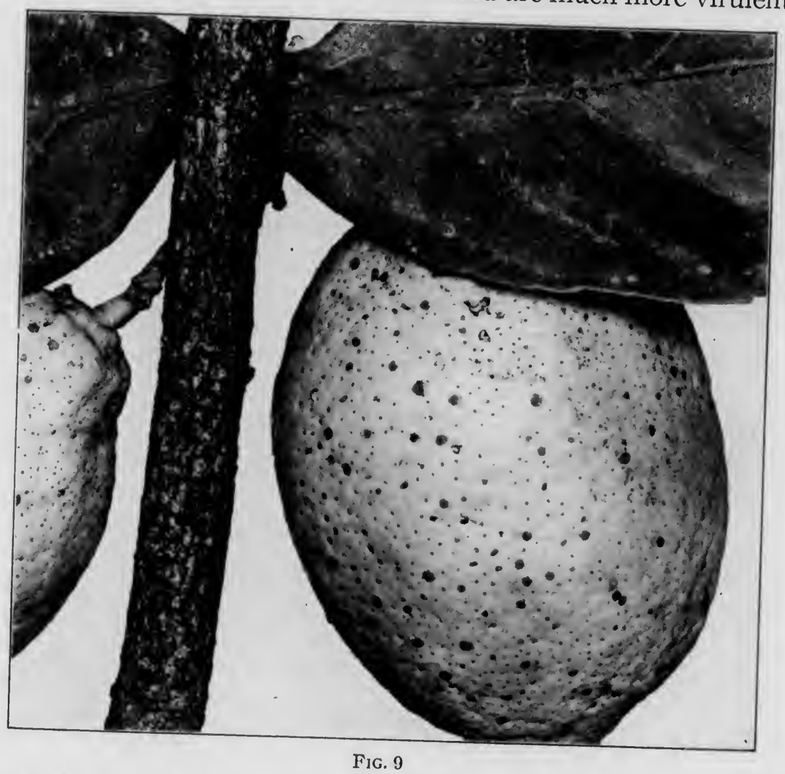


FIG. 9

in their effects on the tree than any other scales on citrus trees. A tree badly infested will be severely injured in a comparatively short time. Often trees are killed in 2 or 3 years by a bad infestation of the red scale. In addition to the injury to the tree, the fruit is made less desirable by the presence of scales on its surface. In Fig. 8 old and young red scales on a section of an orange are shown magnified about ten times, and in Fig. 9 the scales on twig, leaves, and fruit of the lemon are

shown about natural size. From these illustrations a good idea of the appearance of infested trees and fruits can be gained.

The red scale gets its name from the covering of the mature scale, which is reddish in color. The insect beneath the scale, however, is usually yellow. The scales are circular in outline and about the size of an ordinary pinhead. The adult female scale is stationary, as are practically all female scale insects. The male scale, when adult, is a minute two-winged insect. In Fig. 10 is shown an outline drawing of an adult male, magnified about thirty-five times. The insect is orange yellow in color; it has a wing expanse of 1.5 millimeters, and a length of about .6 millimeter. These insects are not strong flyers, but are aided somewhat by the wind. They live for from 1 to 5 days, during which time the females are fertilized.

FIG. 10

Unlike the larva of the black scale, which is hatched from the egg, the larva of the red scale is born alive at the rate of two or three a day for a period of 2 months in summer. It remains beneath the parent scale for a day or so after birth, and then emerges and crawls about for a day and sometimes for 2 or possibly 3 days, when it settles on a leaf, branch, trunk, or fruit. The scales appear like small granules of sulphur on the leaves and fruit. Soon after they settle, they begin to secrete white, cottony fibers, with which they become covered. The females remain fixed beneath this covering for life. In about 2 days this covering, in the case of the female, takes on a more compact appearance and turns reddish in color; also, as time passes, the scale covering continues to become more compact and to increase in size. The scale, just before the first molt occurs, becomes attached to the body of the insect.

In about 14 to 20 days after settling the insects molt and the cast skin becomes a part of the covering. From now on the male and female scales lose all resemblance to each other and could be taken for different insects. During this stage, the characteristic elongated male scale covering is produced; it is twice as long as it is broad, but the length is only two-thirds the diameter of the female scale. The female scale, after molting, continues to increase in size until about 40 to 50 days after birth, when a second molting occurs and a second cast skin about twice the size of the first becomes a part of the scale covering. The second molt brings the female insect to the adult stage. The two cast skins form nearly concentric rings in the covering. Following the second molt, the growth of the scale continues until the total width is about twice that of the second cast skin. Fig. 11 shows different stages in the formation of the scale covering. The scales are magnified about twenty times in the illustration. The size of the adult female scale varies from $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter. The female scale undergoes two molts before reaching maturity and the male scale undergoes four molts in the same period of development.

FIG. 11

Under the elongated scale produced after the first molt the male changes to a propupa in about 30 days after birth; about 10 days later a third molt occurs and the insect is then in the true pupal stage; in this stage it spends 10 or 12 days and then emerges as an adult. The first 3 to 5 days of adult life is spent beneath the scale, after which the male pushes its way from beneath the covering and walks about on the leaf and fruit for a short time and then flies away.

In from 10 to 20 days after the second molt, which is approximately 60 days after birth, the female is fertilized and in about 30 days the first young are produced; the reproduction process continues for from 30 to 60 days, after which the insect dies. Thus, it is seen, the total life of a fertilized female is about

4 or 5 months. In case the female is not fertilized, life may be extended for a somewhat longer period, possibly as long as 3 months after maturity.

The spread of the red scale, like that of the black scale, is dependent largely on outside agencies, such as birds, laydbird beetles, and the shipping of nursery stock and fruit from one locality to another.

Several parasitic and predatory insects prey on the red scale, but they do not hold the pest in check; therefore, extreme care must be taken by growers in combating the insect. Fumigation is the method employed as for other scales.

FIG. 12

35. Yellow Scale.—The yellow scale is similar to the red scale, both in shape and size. If the scale that covers the insect is removed it will be found that the structural characteristics of the two insects are identical and that the color is much the same. The difference between the two scale insects lies mainly in the scaly covering. The yellow scale is distinctly lighter in color, lies flatter on the leaf, and is sometimes slightly larger than the red scale. When the yellow scale insect dies, the yellow covering becomes darker and then it is somewhat

harder to distinguish between the two. Ordinarily, however, the difference between the two scales can be determined when they are examined on the tree.

Aside from these differences there are distinct differences in habit. The yellow scale seems, in most cases, to avoid the trunks and branches and to infest the fruit and leaves. The tree is not injured except in the loss of foliage, and the damage is likely to be much less than that occasioned by the red scale,

FIG. 13

but the fruit, if badly infested, is, of course, unsalable. The yellow scale does not seem to spread as rapidly as the red scale and is less feared by growers; in fact, it is not uncommon to find groves in which there have been scattered scales for several years and in which no effort is made to combat the pests until they become abundant. Fig. 12 shows yellow scales on a pomelo and Fig. 13 shows them on an orange leaf.

The life history of the yellow scale is essentially the same as that of the red scale. The yellow scale is spread by the same agencies that spread the black and the red scale.

Parasitic and predacious insects attack the yellow scale, but do not hold it in check. It is controlled by fumigation, like the other scales.

36. Purple Scale.—The purple scale is not so widely distributed in California as the black, red, and yellow scales, but where it does occur it yields less readily to control than those mentioned, since the eggs are more resistant to fumigation. Leaves, branches, and fruits are attacked and often become completely encrusted; usually only a portion of the tree becomes so completely infested. The insects thrive on the interior, lower parts of the tree and it is here that injury is most apparent. When the scales infest the leaves, a marked yellowing of the leaves occur, and in severe cases many of the branches become leafless.

The purple scale excretes no honeydew, but, like the red scale, it injures the host plant directly by sucking the juices from the tree. When scales are present on immature fruit they have a tendency to delay the coloring. Often a green spot is present about a scale while the rest of the surface of the fruit is yellow The purple scale is attached very firmly to the fruit, and is not removed easily by washing; in fact, ordinary brushing and washing has little effect.

The adult female scale is an elongated, oyster-shaped body varying from $\frac{1}{16}$ to $\frac{1}{8}$ inch in length and is one-third as wide. The female is stationary. The scale covering varies in color from a reddish-brown to a rich purple. The male scale, before the adult stage is reached, is more elongated in proportion to its size, narrower, and much smaller than the female scale. It can readily be distinguished from the female. When adult, the male is a minute, two-winged insect.

The eggs of the purple scale are oval in shape and pearly white in color. They are protected by the scale covering above and by a cottony layer beneath and are covered at all points except the posterior end. It is for this reason that they are so resistant to hydrocyanic-acid gas. From thirty to forty eggs are deposited during a period of 3 or 4 weeks; these eggs hatch in from 15 to 20 days during the summer, and in from

3 to 4 weeks during winter. The period from the time the first eggs are laid until the last ones hatch is from 5 weeks to 2 months. The larvas remain under the protecting scale for a day or two after they are hatched and then emerge and are active for 1 or possibly 2 days, after which they settle down, usually near the parents. The females, after settling down, remain stationary for

FIG. 14

the rest of their existence. The males, on the other hand, as is typical with all scale insects, can move about. The young scales secrete at first a couple of coarse entangling threads that serve as protection until a permanent scale covering is produced.

About 26 days after birth the scales molt, the cast skin becoming a part of the new scale. Up to the first molt there is practically no difference between the male and the female. After

the first molt marked differences occur. The male is narrower and smaller than the female. The male molts again 10 or 12 days after the first molt and passes into the propupal stage. At this stage the true appendages of the male are not fully developed. After 8 or 10 days in this stage, the male changes into the true pupal stage. It remains in this stage for a similar length of time and the true appendages, such as wings, legs, etc., are fully developed. The adult male issues as a winged insect about 60 days after birth.

The female scale, about 26 days after the first molt, molts again and comes to maturity so far as molting is concerned.

The female is fertilized by the male scale as soon as she is

FIG. 15

mature, which is in about 60 days after birth during the summer months. In about 15 days after being fertilized the female begins to deposit eggs, the process continuing for 3 or 4 weeks. The female then dies. It will be seen that the period of development is short. In summer the young larvas begin to appear in about 80 days from the time the parent was a larva; in winter the time from larva to larva may be as long as 120 days, which is the maximum. Three or four generations appear each year.

The relative size and shape of the female and the male is illustrated in Fig. 14, which shows them magnified about twenty-seven times; the male is shown at the right and the female at the left.

Purple scales slightly enlarged are shown on twigs and leaves in Figs. 15, 16, and 17. Those on the twig in Fig. 15 are enlarged about four times; those on the leaf in Fig. 16, about five or six times; and those on the leaf in Fig. 17, about two and one-half times. These figures give some idea of the appearance of the scales magnified under a hand lens, and they show how completely they cover the parts of the tree. The illustrations are made from actual photographs.

The spread of the scale is brought about by shipments of nursery stock and fruit and by being carried by birds, beetles, etc. The scales themselves are not able to migrate far.

Several parasitic and predacious enemies attack the purple

FIG. 16

scale, but they do not hold it in control. Fumigation is used as a control measure, but, due to the protection of the eggs by the scale and the cottony secretion beneath the insect in the egg stage, it is not as easily destroyed by hydrocyanic-acid gas as the other scale pests. Due to the fact that 2 months pass from the time the eggs first appear until the last ones hatch, two fumigations are sometimes made one from 6 weeks to 2 months after the other.

37. Cottony Cushion, or Fluted, Scale.—The cottony cushion, or fluted, scale is a native of Australia, and was introduced in California in 1869. In 20 years it had so spread over the state that it was considered a serious menace to the citrus fruit industry. The fact that the insect was not a serious pest

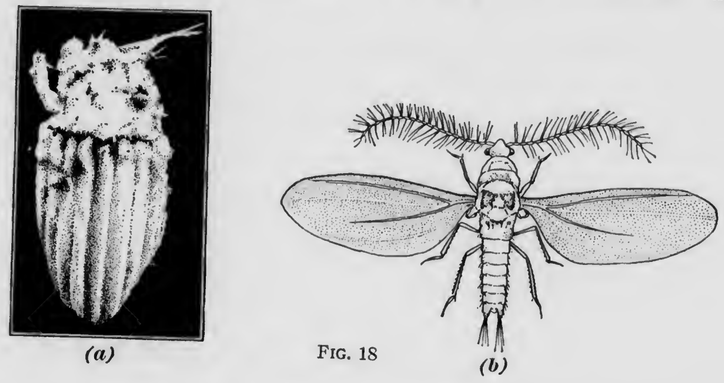
in its native home led to the belief that there must be some natural parasite in its native habitat that controlled it. This was found to be the case, and accordingly, in 1889, the United States Division of Entomology of the Department of Agriculture, introduced the Australian ladybird beetle. In a few years it was reported that the beetle had the cottony cushion scale

FIG. 17

under control; apparently such has been the case ever since. For this reason the cottony cushion scale, although one of the commonest insects found where citrus fruits are grown, is at present considered as a pest of little consequence in citrus groves.

The adult cottony cushion scale has the habit of hiding in crevices and in the forks of the twigs, but infests the larger

branches and the trunk of the tree as well. The adult female scale has a very characteristic appearance which readily distinguishes it from any other citrus scale insect. The scale insect proper is reddish or yellowish brown in color. Each female deposits from 500 to 800 eggs and with them is exuded a liquid that, on exposure to the air, swells greatly and forms a soft cushion in which the eggs are found. This cushion tilts up the posterior end of the scale insect until it literally stands on its head. This pure white cottony mass may reach a length of more than $\frac{1}{2}$ inch and is ridged lengthwise, and this has given the scale its other name, fluted scale. The female scale, unlike the other scales mentioned, travels throughout the greater part of her life, or at least until the egg sac is secreted. The



(a) FIG. 18 (b)

male insect is winged. In Fig. 18 (*a*) is shown the adult female cottony cushion scale much enlarged; in Fig. 18 (*b*) is shown the adult male much enlarged.

In summer, the eggs hatch in from 10 to 12 days; in winter, in about 3 weeks. The larvas settle on the leaves and tender twigs, largely along the veins and midribs of the leaf. Later, most of them migrate to the older twigs and branches and even to the trunk, although in some cases they remain on the leaves. They rarely mature on the fruit. There is great variation in the time of development of the different scales even during the same season. Some will mature in 3 months and others will not mature in less than 4 months or more. There are about three generations a year in Southern California, but, due to irregularity

in development, these generations are not distinct. Young are most abundant in May and June.

In Fig. 19 is shown the trunk and branches of an orange tree infested with the cottony cushion scale.

FIG. 19

38. The cottony cushion scale is controlled by the Australian ladybird beetle and Koebele's ladybird beetle, the adult forms of which are shown respectively in Fig. 20 (*a*) and (*b*). The

Australian ladybird beetle is slightly less than $\frac{1}{4}$ inch in length, and is oval in shape, as shown by the illustration. It is black in color and has red marks. The larva is longer than the adult, often about $\frac{1}{2}$ inch in length; it is of a lead-gray color, has slightly reddish sides, and is often covered with a whitish powder, which comes from the egg case of the cottony cushion scale. The female beetle deposits from 150 to 200 eggs in the cottony sac containing the eggs of the cottony cushion scale. The ladybird eggs hatch in 5 or 6 days and the larvas feed on the eggs of the scale. Following the destruction of the eggs they feed on the scale in all stages. In about 3 weeks they become pupas; the pupal stage is passed in the larval skin on the leaves and limbs of the trees; this stage lasts about a week, and then the mature beetles appear. Copulation soon takes place and other broods are brought forth. The beetles are very prolific and are very efficient in keeping the cottony cushion scale in check. The beetle feeds on its own kind if the scales become scarce, and on account of this destruction of its own kind it is often necessary to replenish the supply of ladybird beetles.

(a) FIG. 20 *(b)*

Koebele's ladybird beetle is smaller than the Australian beetle, being only about $\frac{1}{8}$ inch long. The adults are red and have dark markings; the larva are dark red, and are about $\frac{1}{4}$ inch long. The female deposits small oblong eggs on the egg sacs of the scale and these eggs hatch in a few days. The young enter the egg sac and begin feeding on the eggs and on the young scales. The insects pupate within their larval skins and emerge as adults in about a week. They then mate and soon bring forth another brood. The insects are very prolific, and egg laying continues from spring to fall. They hibernate during the winter.

Growers can usually arrange to secure these predacious insects for their groves from the state horticultural department.

39. Soft Brown Scale.—The soft brown scale rarely occurs in sufficient numbers to be a serious pest of citrus trees. Occasionally a few trees in a grove become seriously infested, but the infestation is usually of short duration They are very efficiently controlled by several parasites. The chief injury caused by the soft brown scales is due to the copious amount of honeydew given off and the resulting growth of sooty mold fungus. They attack principally the leaves and smaller twigs.

The adult scale is oval in outline, it is soft, flat, and varies in color from straw to dark brown. The largest scales attain $\frac{1}{4}$ inch in length and about $\frac{3}{16}$ inch in width.

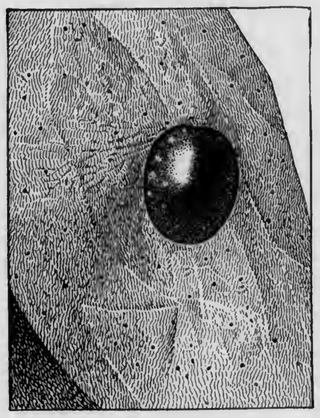


FIG. 21

The soft brown scale, like the red scale, deposits no eggs, the young being born alive. They soon settle on small twigs and leaves, and, in the case of the female, remain fixed. Two molts occur and the young reach maturity in about 65 days, or later if the weather is cold. There are several broods a year, but the young are found most abundantly in May and July.

Two parasites attack this scale, one when the scales are nearly grown, and the other when they are not more than half grown. These parasites aid in holding the pest in control, but in the case of a serious infestation fumigation is necessary.

40. Hemispherical Scale.—The hemispherical scale is troublesome on citrus trees only at times in certain localities. In appearance it resembles somewhat the black scale, but is lighter in color, smaller in size, has a more glossy surface, and does not have the H marking. In Fig. 21 one of these scales is illustrated much enlarged on the leaf of an orange. Two parasites and a ladybird beetle attack the hemispherical scale and help to keep it down. Fumigation for the more serious scale pests is, of course, instrumental in killing many of these scales.

41. The Greedy Scale.—A great variety of plants are attacked by the greedy scale. It is usually found more abundantly on ornamental shrubbery, such as the acacia and laurel, and on many shade trees. Sometimes the greedy scale infests the twigs of citrus trees and older fruits that hang on the tree from the previous year. Such fruits are usually tree-ripe lemons. Since such fruit is of little consequence, the injury does not amount to much.

The greedy scale resembles the San José scale, but is somewhat lighter in color, larger, and much more convex. The scale is thin, and the yellow body beneath can be seen.

A parasite that attacks this scale helps to keep it in control. It can readily be controlled by the fumigation given other scale insects.

42. Citrus Mealy Bug.—The citrus mealy bug is widely distributed over citrus groves of California, but is considered as an important pest only in certain restricted localities, which are apt to be dry during certain seasons of the year. The mealy bug is an insect that approaches the nature of a pest rather periodically, and in many cases will disappear and reappear very suddenly, depending on whether climatic conditions are favorable or unfavorable. Rainy weather has a tendency to hold the mealy bugs in check; dry seasons are particularly favorable for their increase.

All parts of the tree, including leaf, branches, and particularly the fruit, are attacked by this insect. In a severe infestation, masses of insects, eggs, and young may be clustered on the fruit and leaves, usually in sheltered places, as along the midrib or at a junction of the leaf with the stem. A most favorable location is between two oranges or in the navel of navel oranges, as shown in Fig. 22. The mealy bug also secretes a particularly sticky honeydew, which, with the resulting sooty mold, makes a most unsightly fruit and one hard to clean. In the vigorous scrubbing rendered necessary, the fruit is apt to get scratched or bruised, thus giving entrance to the molds that cause decay. In addition to this damage, the drain on the fruit and tree from the withdrawal of sap is a serious matter.

43. The adult female mealy bugs, unlike the scale insects, make no thick and hard scale, do not lose their legs, feelers, or eyes, and are able to move about nearly or quite throughout

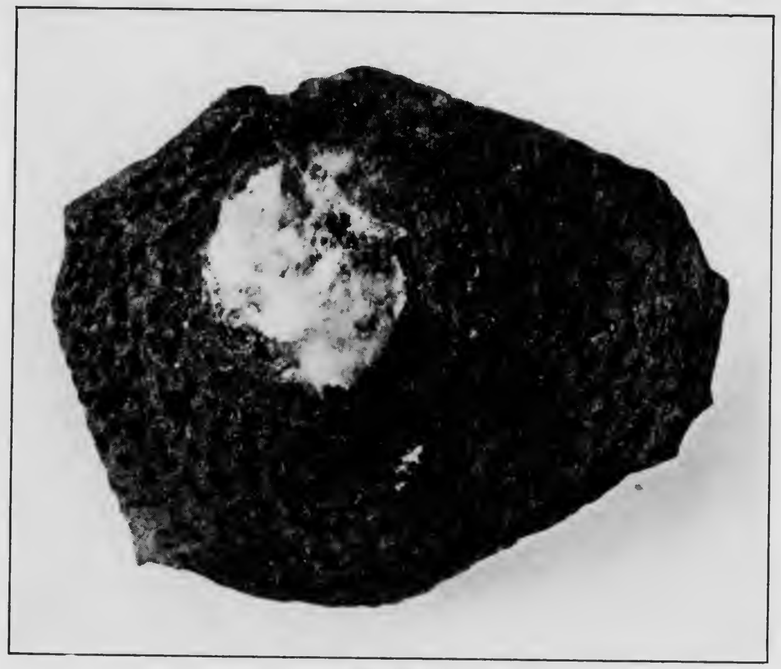


FIG. 22

their existence. They do form some wax, which adheres to them in granules, and gives them their name of mealy bug. In all these respects, the mealy bugs resemble the larvas of other scale insects. The male is a two-winged insect; it dies after the female has been fertilized.

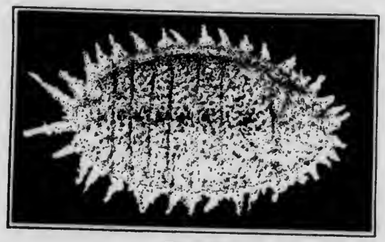


FIG. 23

From 350 to 400 eggs are laid in a cotton-like mass secreted by the female at the time the eggs are deposited. These hatch in from 8 to 18 days, depending on the season, into small larvas, which closely resemble the adult female. They do not migrate very far, because they are busy feeding on the plant juices, attacking the tender foliage

or the young fruits. The male insects soon after they are hatched, spin small white cocoons in which they pupate and from which they emerge as adults about the time the females are half grown. The males die soon after copulation. The females develop for some weeks after copulation, when egg

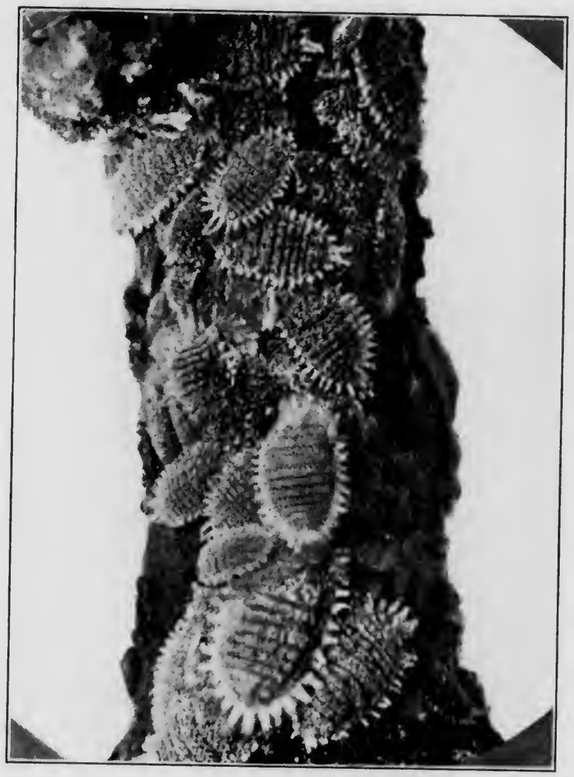


FIG. 24

laying begins. They continue to deposit large masses of eggs, until they become only shriveled, dry skin.

In Fig. 23 is shown an adult female mealy bug much enlarged and in Fig. 24 is shown an orange twig covered with these insects. In Fig. 25 is shown oranges badly infested with mealy bugs. It will be seen from the illustrations how the insects have spread to the surrounding surfaces of the fruit from where the fruit comes in contact.

44. The mealy bug is a soft-bodied insect and is attacked by several parasitic and predacious enemies, which, although they reduce its ravages considerably, do not keep the pest in control. This pest is one of the most difficult to kill in large numbers either by fumigation or by spraying. It seems resistant to the ordinary dosages of hydrocyanic-acid gas used in fumigation, and, on account of being hidden in protected places on the fruit and of having the habit of collecting in masses on the fruit, the insects are not easily reached by spraying. Although

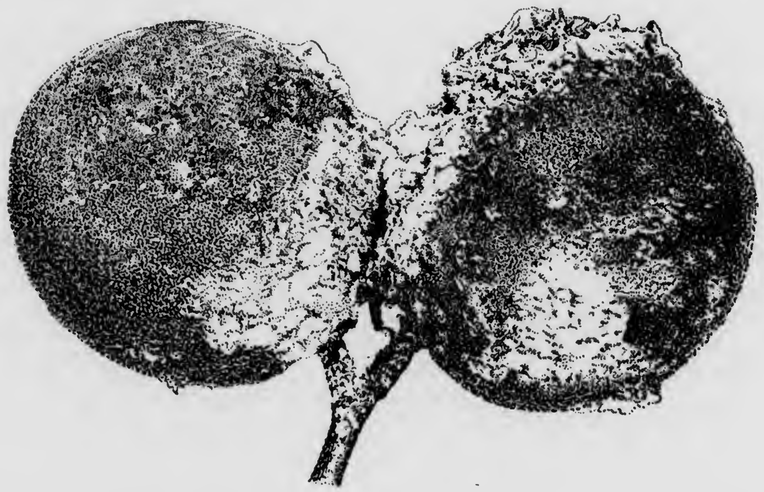


FIG. 25

fumigation kills many of the insects, this is not recommended unless some other pest such as black scale, purple scale, or red scale is present. The most satisfactory control measure is spraying with carbolic-acid emulsion, which is made up of 1 gallon of crude carbolic acid, 8 pounds of whale-oil soap, and 170 gallons of water. The soap and carbolic acid are dissolved in hot water, and an emulsion is made by stirring the mixture into the water. In spraying for this pest, it should be remembered that pressure is the main requisite so that the bugs may be washed from their lodging places, and that the spray may reach all parts of the tree. A pressure of about 175 pounds should be maintained in the pump and a nozzle that will give

a rather coarse driving spray should be used. If the insects are present in large numbers three or four applications a week or so apart may be necessary to control them.

MISCELLANEOUS INSECTS

45. Fuller's Rose Beetle.—A grayish-brown beetle known as Fuller's rose beetle is a pest of citrus trees. A view of this beetle is shown in Fig. 26. Its natural length is shown by the line at the right of the illustration. The beetles feed on the leaves of the trees. Frequently these beetles may be seen clinging to the twigs, the under side of the leaves, and the forks of the smaller twigs. They are nocturnal in their habits and feed at night; during the day they remain quiet and avoid the light. In larger trees where certain parts are very much shaded, that is, in near the trunk of the tree on the under side of large branches, they will sometimes feed during the day. When these beetles are very plentiful in a grove they will almost defoliate some trees. Usually more injury is done by the larvas, though it is not often noticed, to the roots of the tree than the beetles do to the foliage.

FIG. 26

The eggs of the beetle are laid in clusters of from ten to fifty, usually in the bark of the tree. They hatch in from 3 to 4 weeks, and the larvas crawl down the tree to the ground, where they feed on the tree roots. They pupate in the ground and when mature crawl back to the foliage. The beetles are not able to fly, and this fact makes it possible to keep them from getting back to the foliage. The general method is to wrap the tree trunk with a band of cotton. A piece about 4 inches in width is placed around the tree and fastened at the lower part with a string around the tree. The top part of the band is then pulled down over the string and allowed to extend out from the trunk. This makes a barrier

FIG. 27

over which the beetles cannot crawl. Another method of preventing the beetles from crawling up the trunks is to wrap the trunk with a piece of tree tanglefoot paper.

The larvas are difficult to control, but thorough cultivation around the trees is an aid in holding them in check. This exposes the pupas to weather conditions, which they cannot withstand.

46. Diabrotica Soror, or Green Bug.—The Diabrotica soror illustrated in Fig. 27 is a green beetle with twelve black

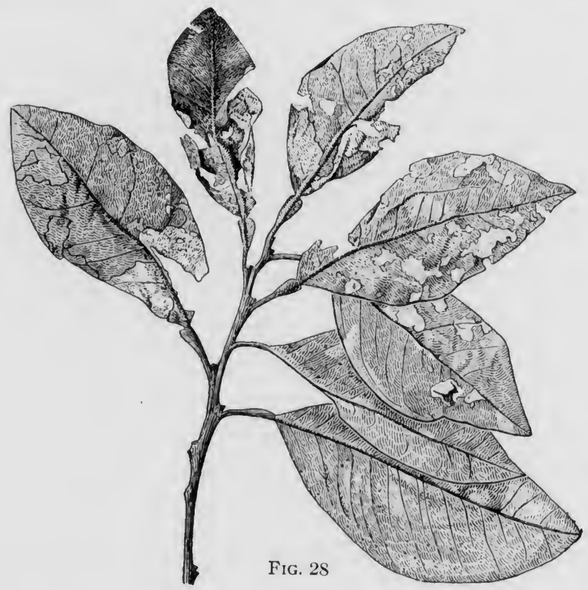


FIG. 28

spots on its wings. It is also known as the green bug and as the twelve-spotted cucumber beetle; it is often mistaken for some form of the ladybird beetles. The insect principally attacks the young, tender growth on the orange trees; it very seldom attacks the lemon. Both the adult and the larva feeds on the trees; the adult attacks the young, tender foliage parts of the tree and the larva attacks the roots. Fig. 28 illustrates the work of this insect on the foliage of the orange.

In the spring eggs are laid around the base of the tree, about $\frac{1}{2}$ inch under the ground. They soon hatch into white grubs,

which begin immediately to feed on the roots. The larvas pupate in the ground and the adults emerge in about 2 weeks and begin feeding on the foliage.

Although the larvas do much damage, it is not generally necessary to resort to control measures for them. The adults, however, should receive attention. If the trees are small and can be easily jarred the beetles can be shaken from them in early morning when they are sluggish on to a sticky or an oiled screen. They can then be collected and destroyed. Another method

FIG. 29

is to spray the tender growth of the trees with poison. A spray consisting of 8 pounds of arsenate of lead to 200 gallons of water will hold the beetles in check.

47. Thrips.—Often, if the blossoms of orange or lemon trees are shaken in the hand, many minute yellowish or brownish insects known as thrips can be seen running around. These insects feed on the blossoms and tender tissues. If not too numerous they do little harm, but if in abundance they may shorten the crop. After the blossom has cast the petals and other temporary structures, it is common for them to feed on

the young pistil or the developing orange, scraping off the epidermis. Their presence in the grove can usually be told by their work on the fruit, the surface of which is scarred. Often a ring like that shown in Fig. 29 is found around the stem end. At times they work down from this ring in streaks. Later the blossom end is attacked, but the marking at this end is less distinct than at the stem end. These growths do not injure the edible qualities of the fruit, but such fruit must, on account of its appearance, be classed as low grade. In addition to the fruit, the leaves and tender growth of the tree are attacked; in a badly infested tree, the growth is injured.

Two species of thrips are responsible for much damage to citrus fruits in California and Arizona. These are the regular *citrus thrip* and the *greenhouse thrip*.

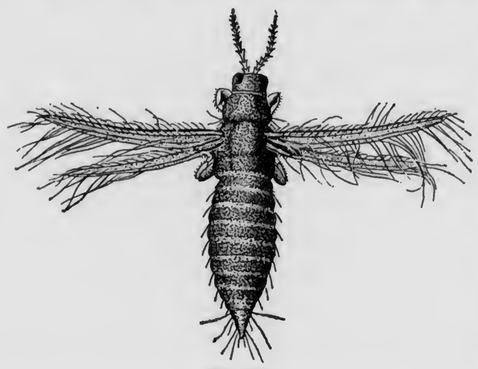


FIG. 30

48. The adult **citrus thrip** is a very small four-winged insect about $\frac{1}{30}$ to $\frac{1}{25}$ inch long and $\frac{1}{100}$ inch wide. Fig. 30 is an illustration of the adult thrip.

The color ranges from dark brown to almost black. The insects can also be recognized by their ability to jump great distances in proportion to their size when disturbed. Under a lens, the wings are seen to consist of a true membrane fringed on all free sides by hairs, which are several times longer than the width of the membrane. Adults of this species occur in early spring and there is a succession of broods up to November.

The thrips spend the winter in the adult form, hibernating in a protected place. In the spring, about May, the adults appear and begin depositing eggs in cracks in the tissue on which they feed. The eggs hatch in about 6 to 10 days from the time they are deposited. The larvas have no wings but in other respects they closely resemble the adults. In from 6 to 8 days they pass into the pupal stage, from which they emerge as adults in from 3 to 5 days. The entire period from the laying of an egg to the egg-laying stage of the second generation is only 20 days, and usually there are from eight to ten generations a year in California. Unless held in check, these insects in a short time become very numerous.

Tobacco decoction is a cheap and efficient remedy for these insects. This can be prepared at home by boiling stems or refuse tobacco in water until a solution the color of weak tea is obtained, or the commercial product can be purchased already prepared. There are several of these commercial preparations on the market which are sold under various trade names. The most popular and the best tobacco preparation on the market is a product sold under the name Black-leaf 40. The 40 signifies a strength of 40 per cent., which is a very concentrated solution. A good formula is: Black-leaf 40, $3\frac{1}{2}$ fluid ounces; commercial lime-sulphur (33°), $2\frac{1}{3}$ quarts; and water, 50 gallons.

It is desirable to put lime-sulphur or soap in the solution, since this causes the tobacco to spread well and at the same time retards evaporation. Also, it causes the tobacco to stick more closely to the leaf. To obtain the same results in spraying with the home-prepared product, 5 gallons of tobacco solution must be substituted in the preceding formula. Also, any of the fish oil soaps, such as whale oil soap, may be substituted for the lime-sulphur; 2 to 5 gallons of soap solution should be used, depending on whether the water is soft or hard. This spray should be applied, in case thrips are numerous, in the latter part of April and repeated at intervals of 10 days until the insects are under control. A strong pressure in the pump of 175 pounds is desirable, so that the spray may be distributed evenly over all parts of the tree.

49. The **greenhouse thrip** is found on citrus trees only in restricted localities, but if infestations are severe it may do more damage than the citrus thrip. The fruit may be infested so badly that the entire surface assumes a pale, silvery appearance. The leaves become mottled and drop off, thus weakening the tree. The adult greenhouse thrip has a yellowish-brown abdomen, a dark-brown head and thorax, and colorless legs,

wings, and antennæ. The eggs hatch in about 10 days, and the larval and pupal stage occupy from 4 to 6 weeks. There is much overlapping of generations, and it has been estimated that as many as twelve generations a year may be produced. The insects feed during all stages of the life cycle.

The remedy and its application for the greenhouse thrip is the same as for the citrus thrip.

50. Orange Tortrix.—The orange tortrix is a gray moth about ½ inch long. The larva burrows into the fruit, usually going no deeper than through the rind. The burrows not only mar the fruit but provide entrance places for molds, rots, etc. In early spring the female lays about fifty cream-colored eggs, usually on the under side of the leaves, but sometimes on the fruit itself. The eggs are deposited in masses and overlap shingle fashion. In about 12 days the larvas hatch and begin feeding, on the fruit or foliage. At first they make several small burrows but later work on one burrow only. A thin network of silk is spun over the entrance. In about 2 months the larvas become full grown. They are then about ½ inch long and are from white to gray in color. During the developing period, the larvas generally remain in the burrows, but on reaching maturity they emerge and seek a place for pupating. If a suitable place is not found, they will return to their burrows and pupate there. The pupal stage lasts from 9 to 12 days, when the insects emerge as moths. Investigations show that about three generations a year are produced.

The principal remedy for this insect is to destroy all dropped fruit in the groves and the culls from the packing houses while the larvas are still in the burrows. In case, however, a bad infestation occurs, spraying with an arsenical poison at the time the larvas are feeding is advisable.

51. Aphids.—Several species of aphids, or plant lice, are found on citrus trees. Generally, the attack is confined to a few shoots on certain trees, and hence the damage is not likely to be severe. The lice suck the juices of the leaves and stems, and the result is a curling of the leaves and a checking of the growth of young shoots.

Predacious and parasitic insects, diseases, and unfavorable weather conditions usually keep aphids under control, but in case of a severe infestation spraying is necessary. Kerosene emulsion, soap and fish-oil wash, and carbolic-acid emulsion and tobacco decoctions are used as spray materials.

52. Citrus White Fly.—The citrus white fly is a serious pest in the southeastern citrus-producing section of the United States, but as yet infestations are very limited in the West, where every possible means are employed to eradicate the pest and prevent its establishment.

The adult fly is about $\frac{1}{10}$ inch in length; the body is yellow,

FIG. 31

and the wings are opaque and covered with a white powder. The fly passes the winter as a mature larva on the under side of leaves; the pupa appears early in the spring. The larva and pupa resemble a soft flat scale, and the development of the insect takes place underneath this scale-like covering. The adult appears about March or April. It emerges from the pupa case by breaking through a T-shaped incision in the top of the skin, or scale. Fig. 31 shows the eggs, pupa, and pupa cases on an orange leaf. Fig. 32 shows the adults on orange foliage.

The nature of the injury by the white fly is similar to that of the black scale, a honeydew being secreted, and this results

in the establishment of sooty mold fungus on the fruit. In addition, the insects may be so numerous on the leaves that they will interfere with the functions of the plant to such an extent that the fruit is practically tasteless. In the West, fumigation is the method employed to control this pest.

53. Orange Maggot.—The orange maggot, shown in Fig. 33 (*a*), is the larva of a small fly. It is a serious pest of

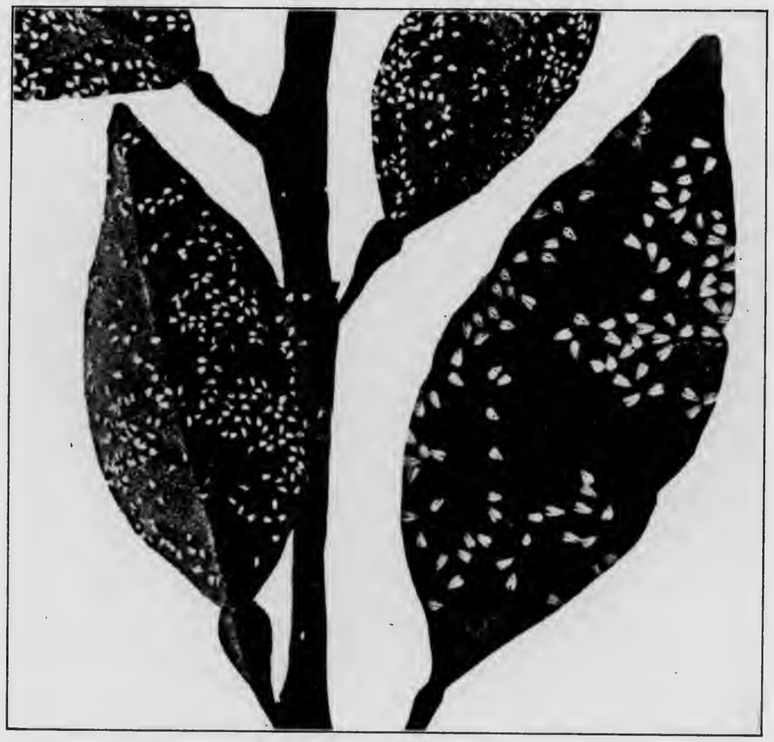


FIG. 32

oranges in Mexico, and, although it has not become established in the western citrus sections of the United States, it should be guarded against. In California a strict quarantine is made against this pest. The pupal form is shown in (*b*), and the adult form in (*c*).

The adult fly is straw yellow and has brownish markings on the wings, which, when spread, measure about $\frac{5}{6}$ inch across.

Each fly will deposit as many as seventy eggs, and these may be distributed on eight to twelve fruits. The eggs hatch into dirty, white-colored larvas, which, when mature, measure slightly less than $\frac{1}{2}$ inch in length. The maggot develops in the fruit similar to the codling moth in the apple. The larva when mature crawls from its place in the fruit and drops to the ground, if the fruit does not drop to the ground before the larva is mature. It then changes to a barrel-shaped light-brown pupa about $\frac{1}{3}$ inch long.

The damage done by this insect is due to the larva feeding in the orange; as many as twenty larvas have been observed in one fruit. This ruins the fruit by directly injuring its quality and at the same time causes it to drop.

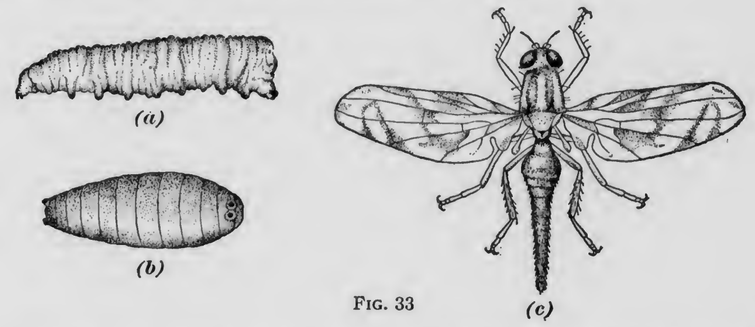


FIG. 33

Where the insect is found control measures consist largely in gathering up any fallen fruit containing the maggots and burning it.

54. Mites.—The mites are not insects but are related to the spider family. Structurally, spiders and mites differ from insects in having usually four pairs of legs instead of three and the body is not divided into three distinct regions, head, thorax, and abdomen, as is characteristic of adult insects. They differ further in that they are resistant to most fumigation dosages.

Three more or less well-known species of mites are injurious to citrus trees and fruits in California. These are the *citrus red spider*, sometimes known as the purple mite, the *six-spotted mite*, and the *silver mite*. These mites occur all over the citrus-

fruit regions and in one place or another do considerable injury by sucking the juices from the leaves; the injury is usually indicated by pale discolorations where their mouth parts have pierced the leaf tissues. This gives a mottled effect to the leaf, which later assumes an ashy-gray or yellowish appearance and has but little chlorophyll, or green coloring matter left in it. Leaves thus affected later fall from the tree. The mites also attack the fruit and produce a grayish or silvery appearance on the rind. It has also been found that mites breed and injure lemons during the curing process if they are not combated.

The mites are most abundant in April, May, and June. Later in the season they largely disappear, although some few may be found on the trees all the year.

55. The **citrus red spider** is dark red in color, about $\frac{1}{10}$ inch in diameter, and nearly round. It is found on both surfaces of the leaf, and when the infestation is severe, the leaf turns a uniform grayish green and has a dry look. Like most members of the spider family, the citrus red spider has eight legs when adult. The adult is also hairy, stiff hairs arising from wartlike projections on the body. This is a feature that distinguishes it from the six-spotted mite and the silver mite, which lack these projections. The males are smaller than the females and are usually present, but eggs may be produced and young hatched without them. The eggs are minute bodies nearly spherical and red in color. They occur singly and are held firmly to the leaf by a group of fourteen silken guy threads attached to the end of a perpendicular stalk, which arises vertically from the upper side of the egg. These threads radiate from the stalk in fourteen different directions and are fastened to the leaf.

The eggs of the citrus red spider are most abundant during May. From one egg to six or seven eggs will be deposited each day after egg laying begins. This process continues for about 4 weeks until thirty to seventy-five eggs have been deposited. The average eggs deposited per day will be two or three, yet there may be days when no eggs will be deposited. The eggs

hatch in about 10 days, in May, into small larvas that have only six legs. This is the chief difference between the larva and the parent, which has eight legs. The larvas, as soon as hatched, at once begin to feed and come to maturity in 12 days, during which time they have molted three times at intervals of 3 days each. After the first molt, the larva acquires another pair of legs, which is the normal number for most spiders and mites. The female spiders are now ready to deposit eggs. Allowing 10 days for the hatching of the eggs, 12 days for development of the insect, and 4 weeks for adult life, it is seen that the life span is 7 weeks, although there may be a new generation every 3 or 4 weeks.

56. The **six-spotted mite,** unlike the citrus red spider, usually feeds on the lower surfaces of the leaves. The mites are most frequently found along the midrib, and colonies extend outwards and forwards in the directions of the cross-veins. The adult insect is pale yellow in color and has six dark spots on the body, from which it derives its name. This mite, like the red spider, is a sucking insect, and the leaves turn yellow in spots as a result of its injury. On the surface of these yellow spots can be found the old cast skins of the insect and black specks covered with a web. The web is more or less conspicuous under a lens. The upper surface of the leaf is swollen upwards corresponding to the depressions on the lower surface and the area is smooth and pale yellowish in color. This spotting with yellow is very different from the uniform grayish appearance which follows the work of the red spider. The leaves, if sufficiently injured, will drop. This insect is not so injurious as the citrus red spider. In its life history, it is very similar to the red spider.

57. The **silver mite** belongs to a very different group of mites than the six-spotted mite. It is quite different in its appearance and habits. It is restricted to a comparatively small area in California and Arizona. It attacks both fruit and foliage of citrus trees. The silver mite usually attacks the fruit first, while the other mites usually first attack the leaves. The contents of the oil glands are sucked out. This

extraction of chlorophyll, or green coloring matter, results in a silvery color on the fruit of the lemon; the ripening orange becomes distinctly browned or russetted and the foliage loses its glossy-green appearance and becomes pale gray in color. On account of this silvery effect on the lemon, which is the principal variety of citrus fruits grown in California where this pest is found, it has been called the silver mite.

The adult mite, unlike the red spider, is shaped like an elongated triangle, that is, it is widest near the head and tapers at a nearly uniform rate to near the posterior end. It is only about $\frac{1}{200}$ inch in length, practically invisible to the unaided eye. Under a lens it is seen to be of light yellow color and has but four legs. The eggs are pale yellow in color; they are smaller than those of the red spider and are laid singly or in small clusters on the foliage or fruit. The eggs hatch in 4 or 5 days in summer and in 10 to 14 days in winter. The young larva, after being hatched soon begins to feed, and after about a week sheds its skin, molts, and passes into the adult stage. A couple of weeks in summer are all that are necessary to bring the silver mite from egg to maturity. In colder weather this period may be doubled.

58. The standard remedy for all mites and spiders is sulphur. This may be applied in the form of a spray, as commercial lime-sulphur solution, or it may be dusted in a dry form over the trees. There are several proprietary brands of commercial lime-sulphur on the market which test about 33° of concentration on the Baumé scale. Lime-sulphur of this degree of concentration should be diluted at the rate of 4 or 5 gallons of the concentrated solution to 200 gallons of water. If the lime-sulphur is not so concentrated, then it must be diluted somewhat less. The lime-sulphur spray kills the mites largely by contact. It is therefore important that the spray be applied in a fine mist so that all the spiders can be reached. A pressure of from 150 to 175 pounds should be maintained in the pump.

The earliest successful treatment for spiders and mites was sulphur applied dry. This is still much used as a satisfactory

remedy. However, satisfactory results are more dependent on weather conditions than is the case with the spray. Nights with more or less moisture and days of bright sunshine with a temperature high enough to vaporize the sulphur are necessary. This temperature should be 75° F. or above, in the shade.

Sulphur is applied with hydrated lime at the rate of 3 pounds of sulphur to 1 pound of lime. The lime serves as a means of cementing the sulphur to the leaves as well as acts as a carrier and a dilutent. It is practically necessary to hit a mite with sulphur in order to kill it. For this reason the sulphur should be finely powdered so that it can be uniformly distributed over all parts of the tree. The sulphur can be applied by machines, of which there are several kinds on the market specially adapted for this purpose.

Either the dry sulphur or the lime-sulphur spray should be used whenever the spiders and mites appear in any considerable numbers. This is usually in early spring or summer, but sometimes treatment is required at other seasons, as the fall or winter.

CITRUS FRUITS UNDER IRRIGATION

(PART 5)

CITRUS INJURIES AND PESTS—(Continued)

INSECT PESTS—(Continued)

FUMIGATION FOR INSECT PESTS

1. For conditions in the West, experience has proved that the fumigation of trees with hydrocyanic-acid gas is the most practical method of controlling most of the serious insect pests of citrus trees. Fumigation is accomplished by enclosing the tree in a tent and generating gas inside by means of chemicals. This gas is poisonous and kills a large proportion of the insects.

2. In California, if a grower desires, he can arrange to have one of the many contracting firms found in the parts of the state where fumigation is necessary do the work for him. These firms make fumigation their business and have all the equipment necessary for conducting the operations. Certain of the citrus associations own fumigating outfits and take care of the groves of the members, the manager purchasing the chemicals and arranging for all of the work. In some of the counties the horticultural commission owns fumigating outfits and does the fumigating for growers under the direction of the county horticultural commissioner. In this case the work is done for what it costs the county, and since the chemicals

can be purchased in large quantities the work is likely to cost less than if it were done by contractors or the growers themselves.

Some growers and companies owning large citrus acreages do their own fumigating. This is very advantageous, for the work can be done at a time when it is likely to do the most good, whereas if it is done by contract, by an association, or by county officers it may have to be done at a time when it will do the least good, since the fumigator is apt to be busy elsewhere when the need for fumigation is most urgent.

3. As a general rule, a fumigation every 2 years will keep the insect pests in check. In case of a very serious outbreak, however, fumigation in successive years might be advantageous, and for the purple scale, the eggs of which are not easily killed, two fumigations in a year may be necessary at times.

4. Materials for Fumigation.—The materials employed for fumigation are sulphuric acid, water, and either potassium cyanide or sodium cyanide. The hydrocyanic-acid gas is produced by the action of the sulphuric acid on the potassium cyanide or on the sodium cyanide. The chemical reaction in the case of potassium cyanide is $2KCn+H_2SO_4=K_2SO_4+2HCn$. The reaction in the case of sodium cyanide is $2NaCn+H_2SO_4=Na_2SO_4+2HCn$.

An imported potassium cyanide designated as 98 to 99 per cent. pure is used almost exclusively for fumigation purposes in California when potassium cyanide is used to generate the gas. A potassium cyanide less pure than 98 per cent. should not be used, as it is very likely to contain sodium chloride, or common salt, as an impurity, and this material, if present, causes a secondary reaction and liberates hydrochloric acid, which reacts with the hydrocyanic-acid gas and decomposes it, thus reducing the quantity of gas available for fumigation.

Sodium cyanide, when used in fumigation work, should be of a good grade and practically free from sodium chloride. Pure sodium cyanide contains practically one-third more cyanide—that is, available hydrocyanic-acid gas—than does pure potassium cyanide. For convenience in expressing the strength of the sodium salt, it is given in terms of the potassium salt. Thus, a pure sodium is known as a 133 per cent. sodium cyanide. This means that it contains 33 per cent. more cyanogen than a pure potassium cyanide does. Experience shows that for fumigation work a sodium cyanide of 124 per cent. purity or above is satisfactory, but that preference should be given to that testing from 126 to 130 per cent.

The sulphuric acid used should be 66° Baumé, which is about 93 per cent. pure. The impurity most commonly found in sulphuric acid is iron sulphate, and although the presence of this material does not seem to be injurious in any way, it is well to have the acid as pure as possible, for the reason that a definite quantity of acid is required to react with a definite quantity of the cyanide. Nitric acid in small quantities is sometimes present in sulphuric acid, but no injurious effects from it have been noticed on the fumigated trees.

Water, although it does not enter into the reaction that produces the hydrocyanic-acid gas, should, nevertheless, be employed in fumigation. It helps to dissolve the cyanide and hastens the reaction with the sulphuric acid. Potassium sulphate, which is one of the materials formed when potassium cyanide and sulphuric acid are brought together, is a solid, and if water is not present or is present in insufficient quantities the potassium sulphate forms a coating on the pieces of cyanide and retards and in some cases prevents the reaction. When the potassium sulphate forms as a solid in the pots used for generating the gas, fumigators speak of it as the *freezing* of the pots. Sodium sulphate, which is a product formed when sodium cyanide is used in fumigation, is soluble in water, and if enough water is present in the residue left in the fumigation pot after the reaction has taken place, no solid matter is found in the pot; on the other hand, if not enough water is used to hold the sodium sulphate in solution the compound will crystallize out and form solid matter, or all of the residue in the pot may become a congealed mass.

When sulphuric acid and water are brought together much heat is generated. In fumigation this heat has an important function, for when the cyanide is introduced into a heated

mixture, hydrocyanic-acid gas is given off more quickly and thoroughly than if the temperature of the mixture were lower.

5. Tree Injury From Fumigation.—If fumigation on healthy trees is done at the right time and in the right manner, there is little danger of permanent injury to fruit or foliage. Occasionally the foliage at the top of the tree, where the quantity of gas is largest, will be slightly burned and will turn black and drop, but the tree will soon put out new growth to make up for the loss. The fruit itself sometimes becomes slightly pitted as a result of fumigation, but the loss thus incurred is more than made up by the destruction of the insects.

On unhealthy trees there is likely to be a heavy dropping of old leaves a few days after the fumigation, and, in many cases, the fruit will be pitted and much of it may drop.

If orange and grapefruit trees are fumigated while the fruit is small, say from the time it sets until it is about an inch in diameter, there is likely to be more or less injury to the fruit. As this period is from April until the first part of August, fumigating should not be done until later in the year unless pests are very serious, and then the dosage should be somewhat weaker than usual.

The trees of some varieties of oranges are more resistant to injury from fumigation than others. The Washington Navels, Valencias, and seedlings are the least susceptible; the Mediterranean Sweet is next, while the St. Michael is still more susceptible.

6. Effect of Fumigation on Parasitic and Predacious Insects.—Fortunately the Scutellista, the ladybird beetles and other insect parasites of scale insects are not so easily killed by fumigation as the scales themselves. Many of these beneficial insects will be on the lower parts of the tree, and of these a large percentage will escape injury; also, for many of those that happen to be on the upper parts of the tree, the dosage will not be heavy enough to kill them.

7. Time for Fumigating.—The work of fumigating is done at night, because experience has shown that there will be much damage to trees and fruit if the fumigating is done

in the daytime. The bright rays of light and the heat from the sun seem to work in conjunction with the hydrocyanic-acid gas and produce injury. If the temperature is higher than 65° F. at night, it is advisable to stop work, on account of the injury that is likely to occur. In regulating the work it has been found to be unsafe to begin in the evening before the sun has disappeared, and the tents from the last trees fumigated should be removed before the sun rises in the morning.

8. Most of the fumigating in California is done between the latter part of August and the latter part of December. The main reason for choosing this period is that it has been found that the black scale, which is widely distributed, and most of the other scale pests, could be successfully combated during those months. Another reason is that young oranges and grapefruit are injured if the fumigating is done between April and the first of August. Young lemons do not seem to be so easily injured as the other fruits mentioned. This is especially advantageous, because the blossoms, young fruit, and mature fruit are on the trees at all seasons of the year.

9. Cost of Fumigation.—The cost of fumigating a grove depends on several factors, the principal ones of which are the size of the trees, the size of the grove, and the dosage used. Large trees naturally cost more to fumigate than small ones, and a contractor will usually quote a greater price per tree if the grove is small than if it is large. In the past the average cost per each fumigation has been from $25 to $40 an acre, the difference in cost being due to the difference in size of trees, size of groves, and dosage used. As a fumigation once every 2 years will usually keep the pests in check, this expenditure needs to be made only once every 2 years. Thus, the average annual cost will be half the cost of a fumigation, or from $12.50 to $20 an acre. The average number of trees to the acre is ninety, and thus the cost per tree for each fumigation is from 28 to 45 cents, an average perhaps of about 30 cents. The average annual cost per tree is then about 15 cents.

EQUIPMENT FOR FUMIGATION

10. In addition to the chemicals used for generating the gas, the equipment necessary for fumigating are tents for covering the trees; poles, derricks, or other devices for placing the tents over the trees; a cart or a wagon for transporting the chemicals from tree to tree; and vessels in which the chemicals are placed when generating the gas.

11. Tents.—What are known as tents are most generally used in the West for covering the trees. These are octagonal in shape, and are made of strips of duck or drill of the regulation

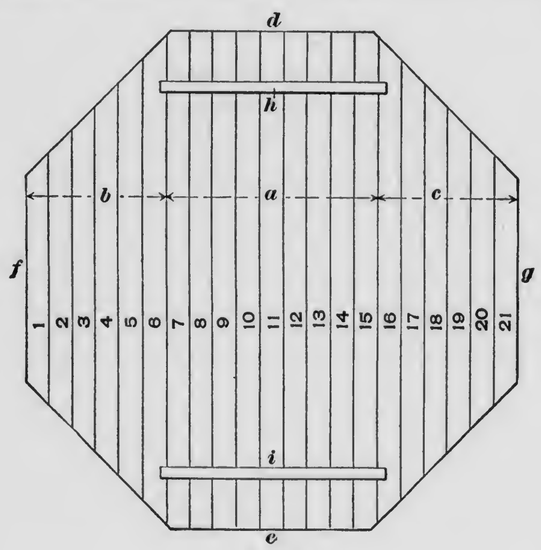


FIG. 1

30-inch width. Often the duck or drill will be found to be ½ inch short of the regulation width, and this lack in width must be allowed for in making the tents.

In Fig. 1 is shown an outline of an octagonal tent. The numbers *1* to *21* indicate the strips of material, which is 29½ inch duck lapped ½ inch at the seams; *a* is the middle section, and *b* and *c* are the side sections; *d* and *e* are known as the ends, and *f* and *g* are known as the sides of the tent; *h* and *i* are reinforcements of duck. The size of the tent is designated

by the distance from one side to the other—that is, from *f* to *g*. Fig. 29 represents a 50-foot tent. In the West, tents of the following sizes are used: 17, 24, 30, 36, 41, 43, 45, 48, 50, 52, 55, 64, 72, and 84 feet. The size to use in a grove varies, of course, with the size of the trees. In California the most used sizes are 36, 41, 43, and 45 feet. Few tents smaller than 36 feet and larger than 45 feet are in use.

12. The material used for making tents should be as tightly woven as it is possible to secure it, for there is less leakage of gas from a tent made of tightly woven cloth than from one made of loosely woven cloth. Experiments made by the United States Department of Agriculture to test the leakage through cloths of different texture have shown a saving of approximately 25 per cent. of the gas in favor of a tightly woven cloth. The tightness of duck or drill can be judged by holding samples of different textures to the light and noting the comparative number of light rays that penetrate through the different samples. In the citrus regions there are many concerns that manufacture fumigating tents, and purchasers usually have no difficulty in getting tents made of cloth of any desired texture.

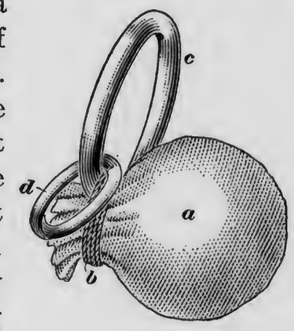


FIG. 2

13. On large sized tents, those over 45 feet, small iron rings are generally attached at certain places for use in fastening the poles or derricks when placing the tent over the tree. The method of using the poles or derricks is explained a little later. The rings are sometimes attached to the tent as shown in Fig. 2. A small portion of the tent is gathered about a wad of burlap or other such material and made into a ball, as shown at *a*; this is bound with a stout cord *b* that passes through the ring *c*, to which is attached a smaller ring *d*, known as a jingler. As the work is usually done at night, the jingler serves a useful purpose in enabling the men putting up the tent to locate the rings readily, which is accomplished by shaking the canvas and thus jingling the rings. Rings with a jingler

are sometimes attached to a 3-foot or a 4-foot piece of manila rope and the rope is looped and sewed to the tents, as illustrated in Fig. 3.

In either method of attachment the rings should be placed from 3 to 5 feet back from the ends of the tent and of a distance apart that accords with the average distance over which trees spread. Since there will be much strain where the rings are attached, it is a good plan to have that part of the tent reinforced with a strip of canvas, which should be at least 3 or 4 feet long, and of the width of the duck or drill in use. These rings are not necessary for tents used for small trees; in fact, they are a disadvantage, as explained later.

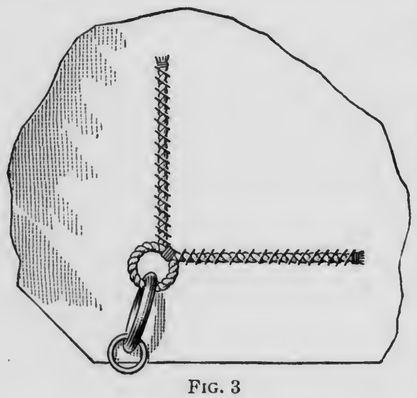


FIG. 3

14. The tents should be shrunk before they are used the first time. A convenient method is to spread them on a lawn and wet them thoroughly by means of a hose. After being shrunk the tents should be marked with measurement lines as shown in Fig. 4. The marks are spaced 1 foot apart and are for the purpose of measuring the cubic contents of the enclosed space around the tree. It is important that the exact cubic contents be known so that the exact dosage of chemicals may be calculated. The tents to be marked should be spread out on a smooth surface, and the marking done with a brush. Lampblack mixed with turpentine makes a satisfactory marking fluid. The numerals should be not less than 5 inches in height.

15. Devices for Placing Tents.—Some mechanical aid is necessary for placing a tent over or removing it from a tree. For small trees that require tents up to 45 feet in size, two stout round poles 2 or $2\frac{1}{2}$ inches in diameter are used. They should be from 6 inches to a foot longer than the height of the trees; those in most common use are 14 or 16 feet long. Straight-

grained Oregon pine is a satisfactory wood for these poles. The lower end is sharpened and the upper end is either rounded, as shown in Fig. 5 (*a*), or narrowed as shown in (*b*). The narrowed end is for use when rings are attached to the tent. A $\frac{1}{2}$-inch to $\frac{5}{8}$-inch rope about 3 feet longer than the pole is attached to the upper end. The illustration also shows two methods of attachment in common use.

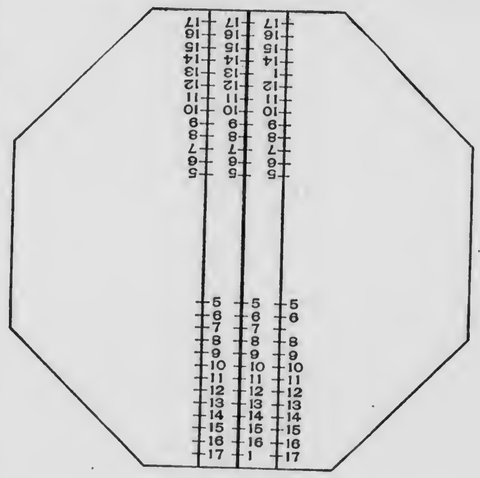


FIG. 4

16. Derricks as shown in Fig. 6 are employed when it is necessary to use tents larger than 45 feet. They have a framework *a* at the base and a rope and pulley attachment *b* is used for raising the tent. A $\frac{1}{2}$-inch or a $\frac{5}{8}$-inch guy rope several feet longer than the derrick is attached to the top. The derrick should be a foot or so longer than the height of the trees. Those in use in California are from 25 to 35 feet in height; they have a bottom diameter of from $3\frac{1}{2}$ to $4\frac{1}{2}$ inches and a top diameter of from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches. The poles are made of straight-grained Oregon pine.

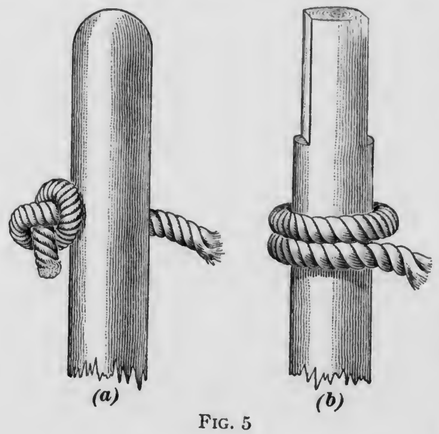


FIG. 5

17. Several machines have been devised to facilitate the placing of tents over the trees. Among other machines, McFadden's is one which has had more prominence than any other. This machine consists of an iron framework mounted on

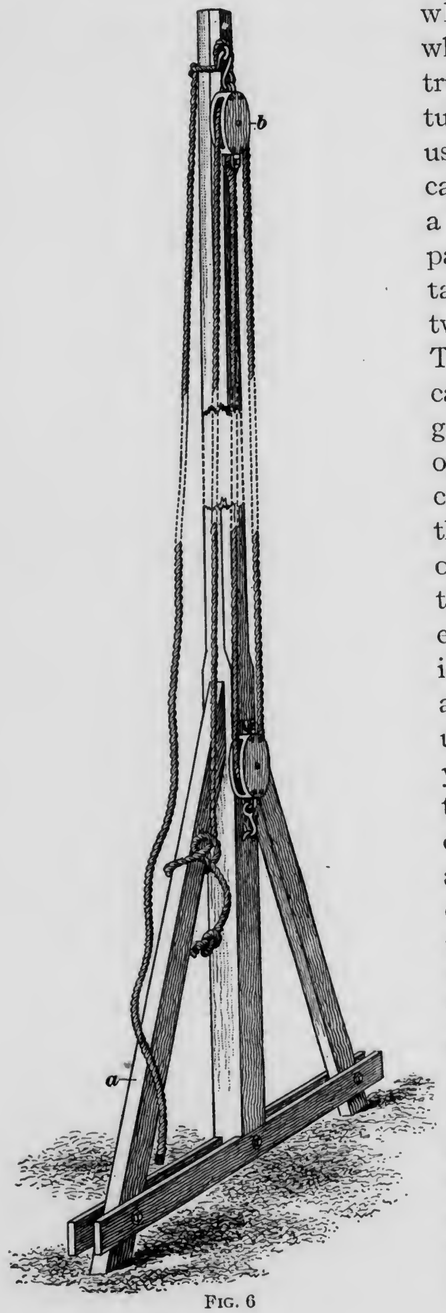


FIG. 6

wheels. Between the wheels at each end of the truck is a long arm of iron tubing. These arms are used as hoisting poles and can be raised or lowered by a system of steel cables passing through pulleys attached to the arms and to two high iron standards. The power for operating the cables is derived from a gasoline engine, which also operates another pair of cables that raise or lower the tent to or from the end of the poles. When everything is in readiness for covering the tree the machine is drawn opposite the tree and the arms are lowered until their ends extend beyond the outer edge of the tree; cables are then let down from the end pulleys and run through two series of rings in the tent, after which the tent is raised to the end of the derricks. The rings are so placed that when the cable is raised about one-third of the tent is gathered up in a series of folds. The derricks are then erected and the tent cables released, when the tent will fall over the tree. This machine raises and

lowers the tent very rapidly and there is less wear on the tree than when the ordinary derrick is used, but it is more expensive.

18. Supply Cart or Wagon.—A push cart or a horse-drawn wagon of some kind is generally used for carrying the chemicals from tree to tree. This conveyance should contain, besides the sulphuric acid, cyanide, and water, scales for weighing the cyanide and a graduate for measuring the sulphuric acid and water. Since the fumigation is done at night, all the vessels, boxes, etc. should be conveniently placed. A push cart devised by R. S. Woglum, of the United States Depart-

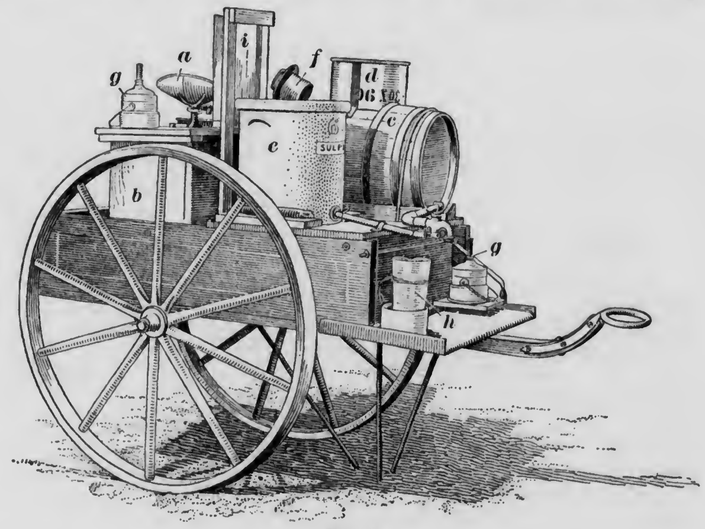


FIG. 7

ment of Agriculture, is shown in Fig. 7. In this illustration, *a* is a pair of scales; *b*, a tin-lined box for cyanide; *c*, a 10-gallon keg for water; *d*, a galvanized-iron basin, which is firmly fastened on the keg and is used for filling it; *e*, an earthenware jar for sulphuric acid; *f*, a lead-lined cover for the sulphuric-acid jar; *g*, torches for light at each end of the wagon; *h*, graduate for chemicals; and *i*, a board on which the dosage schedule is fastened.

Another view of the sulphuric-acid jar on the cart in Fig. 7 is shown in Fig. 8. In this illustration, *a* is a lead-lined lid with a 6-inch opening at the center, around the circumference of which is attached a lead-lined tube that extends downward

several inches and prevents the slopping of acid through the hole; *b* is a lead-lined lid that extends about 6 inches into the lead-lined tube *c*. This opening is used for filling the jar. At the bottom of the jar is a ¾-inch copper or iron pipe for drawing off the acid, and at the end of the pipe is a short piece of rubber tubing fitted with a pinch cock *d*. The pipe must be replaced occasionally on account of corroding; the rubber tubing should be replaced each day.

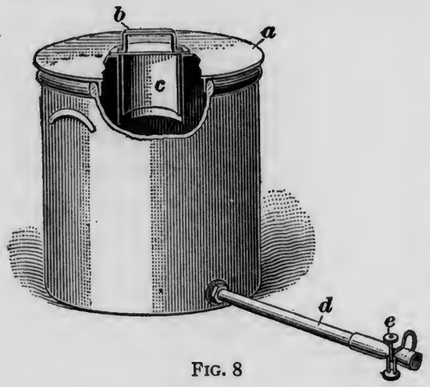


FIG. 8

A cart similar to this fully equipped and with shafts so that it may be drawn by a horse if desired may be purchased in the West. The scales on this cart are sensitive and accurate, and

FIG. 9

the dial is protected by glass; the water tank is of galvanized iron coated with acid-proof paint and the cyanide box is zinc lined and fitted with a hinged cover. Either acetylene or oil lamps are furnished with this outfit.

19. One-horse wagons equipped for carrying chemicals are used in some outfits in preference to the push cart. These, of course, have the advantage of lessening the work for the men. In Fig. 9 is shown a horse-drawn supply wagon used by the San Diego Fruit Company that has many commendable features. The acid and water are held in vessels in the front of the cart, and the liquids are conducted through pipes controlled by stop-cocks *a* to the rear where they empty directly into graduated vessels *b*, the water in one vessel and the sulphuric acid in the other. The person measuring the acid and water allows the vessels to fill to the required height, and then, by means of stop-cocks *c*, allows the liquids to pass into the generator *d* below. A second generator *e* is in readiness. The cyanide is held in a box *f* at the rear of the cart, and is weighed on the scales *g*.

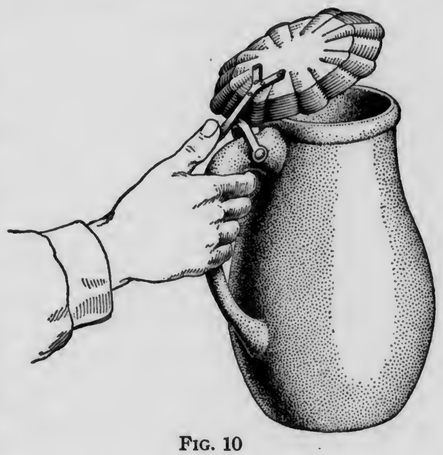


FIG. 10

20. Generating Vessels.—In Fig. 10 is shown the style of vessel most generally used in California for generating the gas under the tent. It can be purchased in 1½-, 2-, and 3-gallon sizes. The 1½-gallon size is used for a dosage of 15 ounces or less of cyanide, the 2-gallon size for a dosage of 20 ounces, and the 3-gallon size for a dosage of 30 ounces. If more than 30 ounces is required, two generators are used. As purchased, the generators usually come without covers, but fumigators have found that a cover similar to the one shown in the illustration will prevent the splashing out of much of the mixture,

which, being largely sulphuric acid, burns holes in the tents. In addition, if an open generator is used, the gas has a tendency to rise straight in the air. Frequently, if the generator is directly below the foliage of the tree, many of the leaves are burned and ultimately drop. This burning of the leaves is known as chimney burning and the result of this burning, which is a heavy dropping of the leaves, is known as the chimney effect. Covers on the generator will eliminate chimney burning by causing the gas to be more diffused with surrounding air as it comes from the generator. The cover pictured in the illustration was devised by R. S. Woglum, of the United States Department of Agriculture. The cover is copper and is stamped to a concave form with corrugations which allow the escape of the gas, but not so rapidly as when no cover is used.

DOSAGE

21. The dosage, or quantity of chemicals to use will vary with the size of the tree and the insect or insects to be combated. To calculate the dosage for a tree the cubic space enclosed by the tent must be known. Not all trees after they are covered with a tent assume exactly the same shape, but for all practical purposes they may be assumed to take the shape of a cylinder surmounted by a hemisphere, and these are the geometric figures used in computing dosages. To ascertain the cubic contents accurately, it is necessary to know several measurements, but experience has shown that if the longest distance over the tree from the ground on one side to the ground on the opposite side and the distance around the bottom are used as factors and the cubic contents computed on this basis, the dosage can be determined with sufficient accuracy.

22. When fumigating, it is necessary that the measurements be ascertained quickly and with a fair degree of accuracy. For determining the distance over the tree, use is made of the scale of feet marked on the tents. The scale on each side begins at the top of the tent and the figure on the scale at the point where it reaches the ground shows the distance from

the top to the bottom on each side, and the exact distance over the tree can be found by adding these figures, provided one of the lines on which the scale is marked is over the exact center of the tree. In practice, however, no attempt is made to get this exact.

FIG. 11

The distance around the tree is best determined by means of a tape line, although in many fumigating outfits pacing around the tree is deemed sufficiently accurate. However, since different men have a different length of pace, the use of a tape line is especially advised.

A tape line fitted to a half-inch straight iron rod, as shown in Fig. 11, is handy for making the measurements. When measuring a tree the rod is stuck into the ground, and the measurer then passes around the tree with the tape line, which shows the distance in feet. A tented tree with tape line around it is shown in Fig. 12.

23. To avoid making computations while fumigating, schedules are made that give the dosage for trees of different

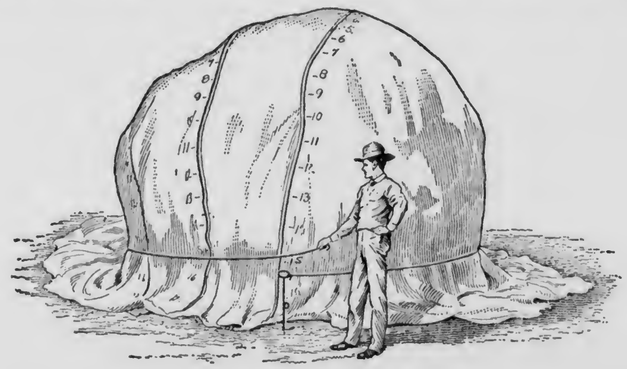


FIG. 12

measurements. The dosage differs according to the insects to be combated and whether potassium cyanide or sodium cyanide is used. In Figs. 13, 14, 15, and 16 are given dosage

schedules for both potassium cyanide and sodium cyanide for use in California as worked out by R. S. Woglum, of the United States Department of Agriculture. In these schedules the top horizontal line of numbers and each fifth horizontal line represents the distance in feet around the bottom of the tent, and the vertical line of numbers at the left represents the distance in feet over the tent. The dosage in ounces of cyanide for any tree that comes within the measurements given in the schedule is found in the square where the vertical column headed by the distance around the tree intersects the horizontal column that represents the distance over the tree. In determining, for example, the dosage for a tree that is 40 feet around and 28 feet over, all that is necessary is to find the intersection of 40 feet on the horizontal line and 28 feet on the vertical line; in the case of the dosage schedule shown in Fig. 13, this is 11, which is the number of ounces of potassium cyanide for the tree.

24. Fig. 13 is potassium cyanide dosage schedule No. 1. It is recommended for purple scale. The length of exposure should be 1 hour.

Fig. 14 is potassium cyanide dosage schedule No. ¾. It is worked out for a dosage of approximately three-fourths the strength of that given in dosage schedule No. 1, and is for red and yellow scales. The exposure should be 45 minutes. For the black scale the dosage depends on the stage of the insect. The best time to combat this pest is when a large proportion of the insects are in the early stages of development. Usually this time will be late summer or early autumn. When the scales are in the early stage the dosage schedule is No. ¾, and the exposure is 45 minutes. In case, however, fumigation is to be done at a time when all stages of the black scale are found on the trees, a full No. 1 dosage schedule should be used and the exposure should be 1 hour. In case more than one kind of scale infests groves, the schedule used should be strong enough to kill the most resistant scale. Thus, if purple and black scales in the earlier stages are found, the full No. 1 dosage schedule should be used, and the exposure should be for 1 hour.

DISTANCE AROUND IN FEET / DISTANCE OVER IN FEET

over	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	over
10	2	2	2	2	2																							10
12	2	2	3	3	4	4																						12
14	3	3	3	4	4	4	5	5	5	5	5	6																14
16	3	3	4	4	5	5	5	5	5	6	6	6	7	7														16
18	3	4	4	5	5	5	6	6	6	6	6	7	7	8														18
			20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
20			4	5	5	6	6	6	6	7	7	8	8	8	9	9	10	10										20
22					6	6	6	7	7	7	8	8	9	9	10	10	10	11										22
24						6	7	7	8	8	8	9	10	10	11	11	12	12										24
26							7	8	8	9	9	10	11	11	11	12	13	13	13	14	15	15						26
28								8	9	10	10	11	11	12	12	13	14	14	14	15	16	16						28
								30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
30								9	10	11	11	12	12	13	13	14	15	15	15	16	17	18	18	19	20	21	21	30
32											12	13	13	14	15	16	16	16	17	17	18	18	19	20	21	21	22	32
34												13	14	15	16	17	17	18	18	19	19	20	21	21	22	22	23	34
36												14	15	16	17	17	18	19	20	20	21	22	22	22	23	24	25	36
38													16	16	17	18	19	20	21	21	22	23	23	24	24	25	26	38
													40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
40													16	17	18	19	20	20	21	22	23	24	24	25	26	26	27	40
41														18	19	20	20	21	22	23	24	24	25	26	26	27	28	41
42															20	20	21	22	23	24	25	25	26	26	27	28	28	42
43																21	22	22	23	25	25	26	26	27	27	28	29	43
44																		23	23	25	26	26	27	27	28	29	29	44
																		50	52	54	56	58	60	62	64	66	68	
45																		23	25	26	26	27	27	28	29	30	30	45
46																		24	26	26	27	27	28	29	29	30	31	46
47																		24	26	27	27	28	29	29	30	31	32	47
48																		25	26	27	28	29	29	30	31	32	32	48
49																		25	27	28	28	29	30	30	31	32	33	49

FIG. 13

DISTANCE AROUND IN FEET / DISTANCE OVER IN FEET

over	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	over
10	2	2	2	2	2																							10
12	2	2	3	3	3	3																						12
14	3	3	3	3	3	3	4	4	4	4	4	5																14
16	3	3	3	3	4	4	4	4	4	5	5	5	5	5														16
18	3	3	3	4	4	4	5	5	5	5	5	5	5	6														18
			20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
20			3	4	4	5	5	5	5	5	5	6	6	6	7	7	8	8										20
22					5	5	5	5	5	5	6	6	7	7	8	8	8	8										22
24						5	5	5	6	6	6	7	8	8	8	8	9	9										24
26							5	6	6	7	7	8	8	8	8	9	10	10	10	11	11	11						26
28								6	7	8	8	8	8	9	9	10	11	11	11	11	12	12						28
								30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
30								7	8	8	8	9	9	10	10	11	11	11	11	12	13	14	14	14	15	16	16	30
32											9	10	10	11	11	12	12	12	13	13	14	14	14	15	16	16	17	32
34												10	11	11	12	13	13	14	14	14	14	15	16	16	17	17	17	34
36												11	11	12	13	13	14	14	15	15	16	17	17	17	17	18	19	36
38													12	12	13	14	14	15	16	16	17	17	17	18	18	19	20	38
													40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
40													12	13	14	14	15	15	16	17	17	18	18	19	20	20	20	40
41														14	14	15	15	16	17	17	18	18	19	20	20	20	21	41
42															15	15	16	17	17	18	19	19	20	20	20	21	21	42
43																16	17	17	17	19	19	20	20	20	20	21	22	43
44																		17	17	19	20	20	20	20	21	22	22	44
																		50	52	54	56	58	60	62	64	66	68	
45																		17	19	20	20	20	20	21	22	23	23	45
46																		18	20	20	20	20	21	22	22	23	23	46
47																		18	20	20	20	21	22	22	23	23	24	47
48																		19	20	20	21	22	22	23	23	24	24	48
49																		19	20	21	21	22	23	23	23	24	25	49

FIG. 14

DISTANCE OVER IN FEET	DISTANCE AROUND IN FEET																											
	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
10	2	2	2	2	2																							10
12	2	2	3	3	3	3																						12
14	3	3	3	3	3	3	4	4	4	4	4	5																14
16	3	3	3	3	4	4	4	4	4	5	5	5	5	5														16
18	3	3	3	4	4	4	5	5	5	5	5	5	5	6														18
			20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
20			3	4	4	5	5	5	5	5	5	6	6	6	7	7	8	8										20
22					5	5	5	5	5	5	6	6	7	7	8	8	8	8										22
24						5	5	5	6	6	6	7	8	8	8	8	9	9										24
26							5	6	6	7	7	8	8	8	8	9	10	10	10	11	11	11						26
28								6	7	8	8	8	8	9	9	10	11	11	11	11	12	12						28
								30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
30								7	8	8	8	9	9	10	10	11	11	11	11	12	13	14	14	14	15	16	16	30
32											9	10	10	11	11	12	12	12	13	13	14	14	14	15	16	16	17	32
34												10	11	11	12	13	13	14	14	14	14	15	16	16	17	17	17	34
36												11	11	12	13	13	14	14	15	15	16	17	17	17	17	18	19	36
38													12	12	13	14	14	15	16	16	17	17	17	18	18	19	20	38
													40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
40													12	13	14	14	15	15	16	17	17	18	18	19	20	20	20	40
41														14	14	15	15	16	17	17	18	18	19	20	20	20	21	41
42															15	15	16	17	17	18	19	19	20	20	20	21	21	42
43																16	17	17	18	19	19	20	20	20	20	21	22	43
44																		17	18	19	19	20	20	20	21	22	22	44
																		50	52	54	56	58	60	62	64	66	68	
45																		17	18	19	20	20	20	21	22	23	23	45
46																		18	19	20	20	20	21	22	22	23	23	46
47																		18	19	20	20	21	22	22	23	23	24	47
48																		19	20	20	21	22	22	23	23	24	24	48
49																		19	20	21	21	22	23	23	23	24	25	49

FIG. 15

DISTANCE OVER IN FEET	DISTANCE AROUND IN FEET																											
	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
10	2	2	2	2	2																							10
12	2	2	3	3	3	3																						12
14	3	3	3	3	3	3	3	3	3	3	3	4																14
16	3	3	3	3	3	3	3	3	3	4	4	4	4	4														16
18	3	3	3	3	3	3	4	4	4	4	4	4	4	5														18
			20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
20			3	3	3	4	4	4	4	4	4	5	5	5	5	5	6	6										20
22					4	4	4	4	4	4	5	5	5	5	6	6	6	6										22
24						4	4	4	5	5	5	5	6	6	6	6	7	7										24
26							4	5	5	5	5	6	6	6	6	7	8	8	8	8	8	8						26
28								5	5	6	6	6	6	7	7	8	8	8	8	8	9	9						28
								30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
30								5	6	6	6	7	7	8	8	8	8	8	8	9	10	11	11	11	11	12	12	30
32											7	8	8	8	8	9	9	9	10	10	11	11	11	11	12	12	13	32
34												8	8	8	9	10	10	11	11	11	11	11	12	12	13	13	13	34
36												8	8	9	10	10	11	11	11	11	12	13	13	13	13	14	14	36
38													9	9	10	11	11	11	12	12	13	13	13	14	14	14	15	38
													40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	
40													9	10	11	11	11	11	12	13	13	14	14	14	15	15	15	40
41														11	11	11	11	12	13	13	14	14	14	15	15	15	16	41
42															11	11	12	13	13	14	14	14	15	15	15	16	16	42
43																12	13	13	14	14	14	15	15	15	15	16	17	43
44																		13	14	14	14	15	15	15	16	17	17	44
																		50	52	54	56	58	60	62	64	66	68	
45																		13	14	14	15	15	15	16	17	17	17	45
46																		14	14	15	15	15	16	17	17	17	17	46
47																		14	14	15	15	16	17	17	17	17	18	47
48																		14	15	15	16	17	17	17	17	18	18	48
49																		14	15	16	16	17	17	17	17	18	19	49

FIG. 16

25. In Fig. 15 is given sodium cyanide dosage schedule A. This schedule, if 124 to 130 per cent. sodium cyanide is used, will give practically the same results as potassium cyanide dosage schedule No. 1. In Fig. 16 is given sodium cyanide dosage schedule ¾ A. This schedule is about three-fourths the strength of dosage schedule A, and will give about the same results as potassium cyanide dosage schedule No. ¾.

Sodium cyanide schedules A and ¾ A should be used for the same insects as potassium cyanide dosage schedules No. 1 and No. ¾, and the time of exposure should be the same.

26. In case potassium cyanide is used for fumigating, the proportions of the chemicals are 1 part of potassium cyanide, 1 part of sulphuric acid, and 3 parts of water. This is known as the 1–1–3 formula and is the one recommended by the United States Department of Agriculture. In case sodium cyanide is used, the proportions recommended by the government experts are 1 part of sodium cyanide, 1½ parts of sulphuric acid, and 2 parts of water. This is known as the 1–1½–2 formula.

PROCEDURE IN FUMIGATION

27. It is well to cultivate the ground just before the grove is fumigated, as the tents will lie closer to the ground and there will be less leakage of gas than when the ground is weedy or rough. An additional advantage of smooth ground is that the chemicals can be moved over the ground easily.

Preparatory to fumigating, the person in charge of the work should look over the grove and decide in which direction the tents can be pulled to the best advantage. Usually a row one way across a field is covered at a time, and after the trees are fumigated the tents are pulled to the next parallel row, and so on across the grove. The direction the tents can be pulled to advantage will depend on the arrangement of trees, the length of the rows, the slope of the land, the direction of the irrigating furrows, if any, and the location of the water supply. In case no source of water borders the grove, several barrels of water should be placed at one end of the first row to be

fumigated. Carboys of acid should be placed where they will be of convenient access.

28. After having decided on the direction in which the tents should be pulled, a tent and a generating pot are dropped at each tree in the first row. The tent pullers then unfold the tents and place them with one end facing the tree on the side away from the direction in which they are to be pulled. In case poles are to be used, two are necessary to get a tent over a tree. The first step is to attach the tops of the poles to the edge of the tent. If rings are attached to the tent, the poles are placed in them; if no rings are attached to the tent, the pole is fastened as shown in Fig. 17. On small tents the latter method is the most satisfactory, as it is quickly done and the tent is not subjected to undue wear; in addition, the tent puller can gauge the distance between poles by the width of the tree to be covered.

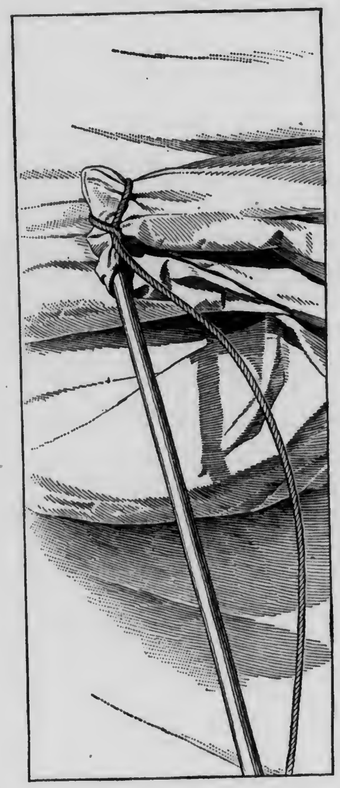


FIG. 17

The successive stages of pulling a tent over a tree by means of poles are shown in Figs. 18 to 22. Fig. 18 shows the poles fastened to the top of the tent and two pullers standing with the guy ropes in their hands and the bottom of the poles braced by their feet and ready to elevate the tent. Fig. 19 shows the tent raised a distance in the air and the ends of the poles still braced on the ground by the feet. When the tent has reached a height that the poles will not slip, the pullers move back to get a better leverage on the pole. The pulling at the later stages should be sidewise as well as forwards. Fig. 20 shows the poles nearly vertical; Fig. 21

shows the tent raised to the top of the tree; and Fig. 22 shows the tent nearly over the tree. When the tree is fully covered

FIG. 18

the poles are removed and the edges of the tent kicked in toward the base of the tree until it hangs straight, as shown in Fig. 23.

29. After the trees in the first row have been fumigated the tents are pulled to the trees in the next row. The tent is not lowered to the ground and then raised over the tree, but is pulled directly from one tree to the other; it is less work to pull a tent from one tree to another than to raise it from the ground to the tree.

The successive steps in pulling a tent from one tree to another are shown in Figs. 23 to 26. The poles are fastened to the

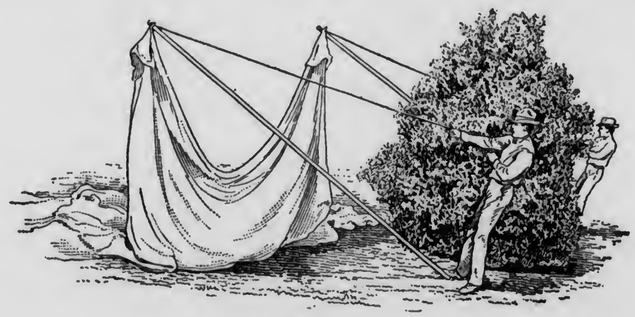


FIG. 19

tent and laid on the ground and the ends held by the feet as shown in Fig. 23, or the ends of the poles can be fastened to

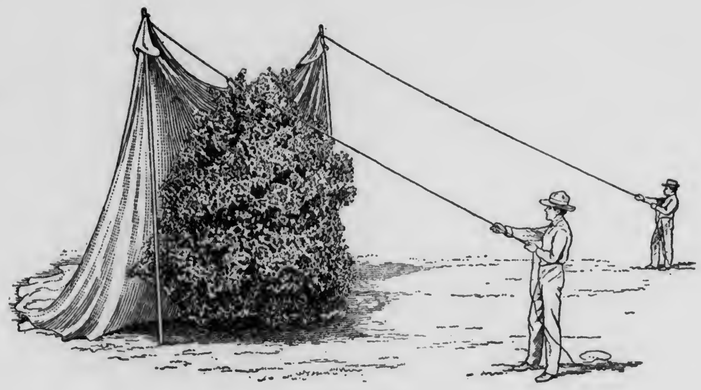


FIG. 20

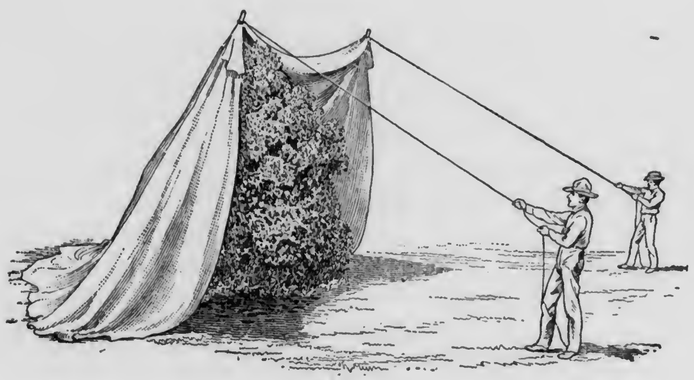


FIG. 21

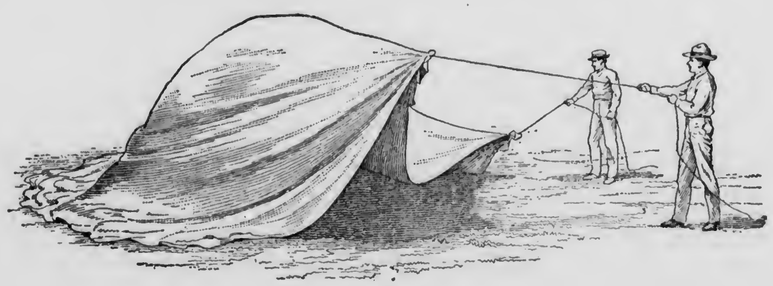


FIG. 22

the tent and leaned against the tree as shown in Fig. 24. The tent is then pulled until it is in the position shown in Fig. 25, when the pullers move away from the base of the poles, and

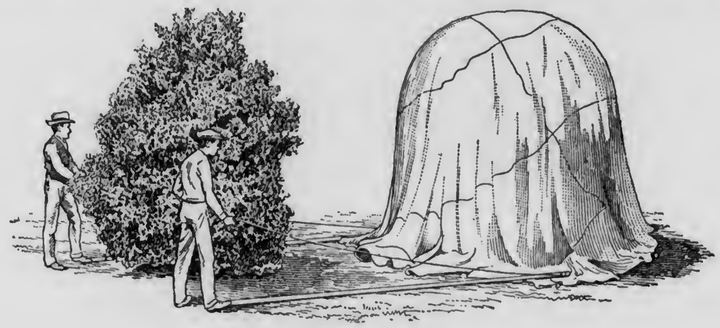


FIG. 23

pull the tent to the position shown in Fig. 26, and then the tree is entirely covered as when the tent is first erected.

30. Derricks such as illustrated in Fig. 6 are employed when large trees are to be fumigated. Four men and two derricks are necessary to get a tent over a tree. In Figs. 27 to 30 are shown the successive steps in covering a tree by means of derricks. The two derricks are placed in position at the sides of the tree, and the men are stationed as shown in Fig. 27. The men at the base of each derrick then brace their feet and

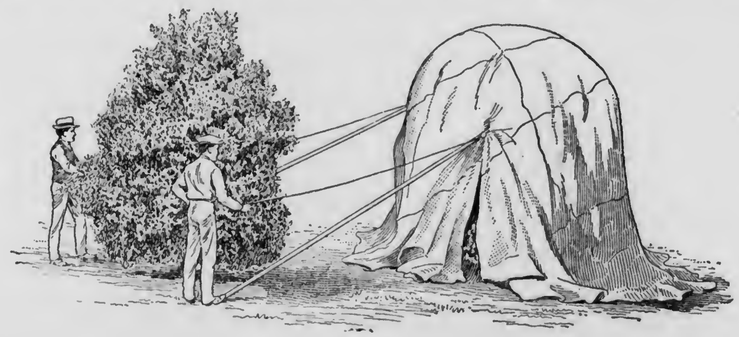


FIG. 24

pull with the guy ropes and two other men assist in lifting the derricks. Fig. 28 shows them partly raised; when they are nearly vertical the tent is attached to the pulley rope by means

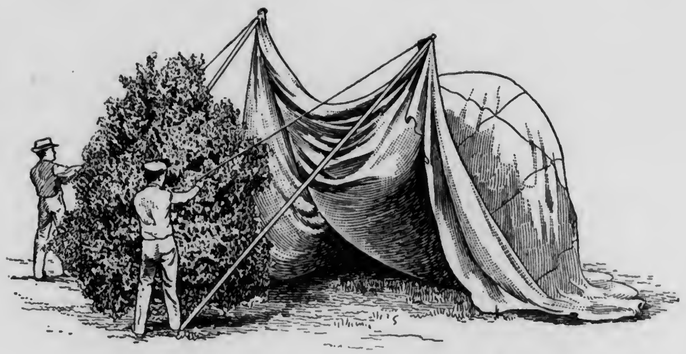


FIG. 25

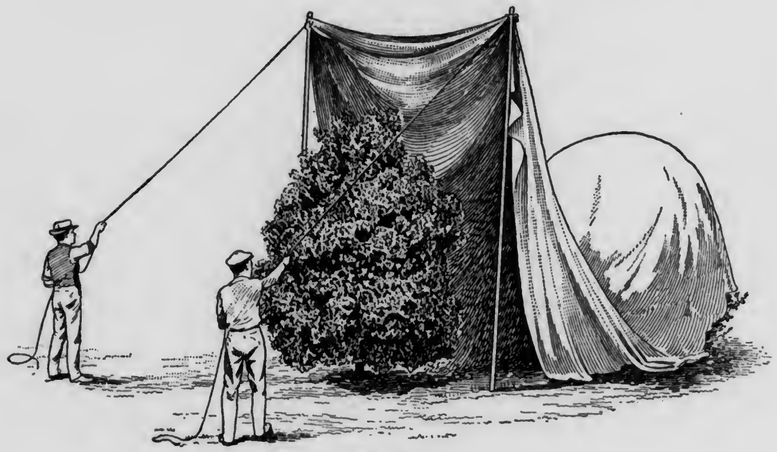


FIG. 26

FIG. 27

of the rings illustrated in Fig. 2, and the tent is pulled to the top of the derricks. Two stages of the work are illustrated in Figs. 29 and 30. After the tent has reached the stage

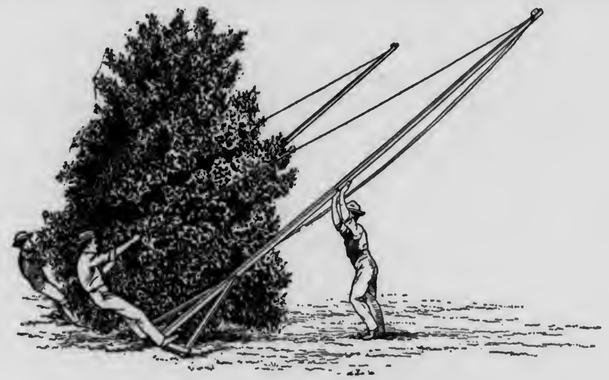


FIG. 28

shown in Fig. 30, the guy ropes are pulled, which causes the derricks to fall and bring the tent over the tree. The method

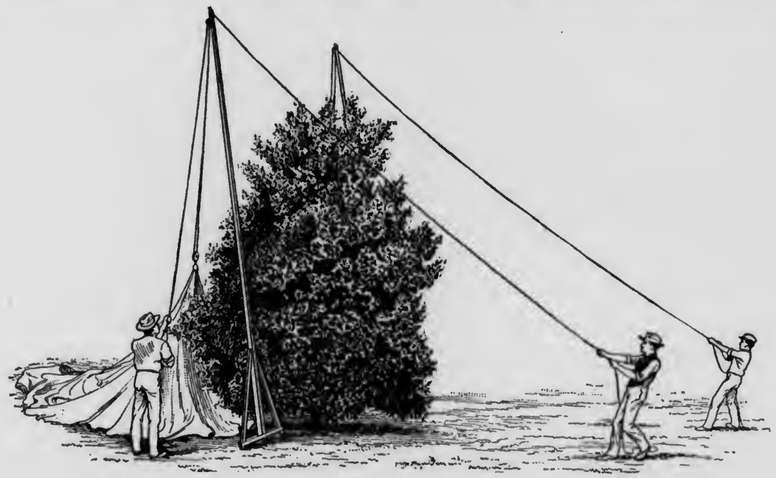


FIG. 29

of pulling a tent from one tree to another by means of derricks is similar to that described when poles are used.

31. Following the placing of the tents, the cart or wagon is started at one end of the row and each tree of the row is

dosed. Three men are necessary for the dosing. One man measures the tree and has the generator in readiness for the chemicals; one man weighs the cyanide; and one man measures the acid and the water. The procedure is about as follows: The man who measures the trees secures his measurements of the first tree in the row and calls them out to the man who weighs the cyanide. The cyanide man then determines the dosage from a schedule that is fastened on the cart or wagon, informs the acid man how much acid and water are required, and weighs the cyanide. The water is then measured by the acid man and poured into the generating vessel; the acid is

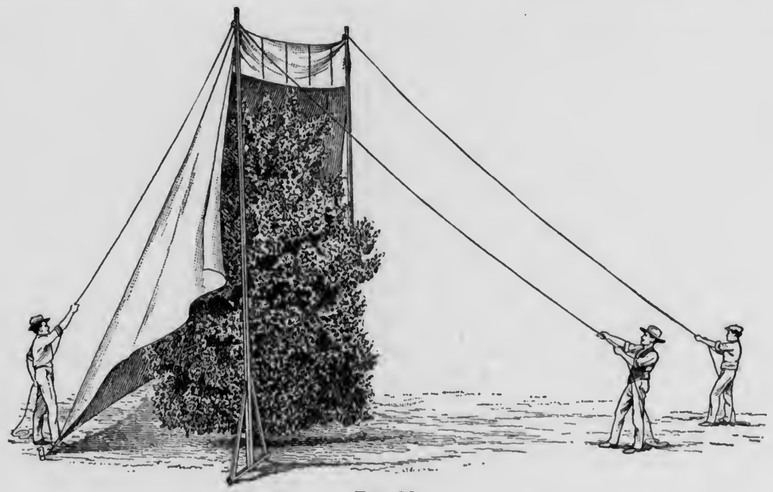


FIG. 30

next measured and poured into the water. The acid man then takes the generator containing the acid and water mixture in one hand and the cyanide in the other and walks to the tree to be dosed. After the cyanide man has raised the edge of the tent, the acid man places the generator beneath the tent near the base of the tree. He then pours the cyanide into the generator, and drops the edge of the tent. In the meantime, the estimator passes to the next tree, secures his measurements and calls them back to the cyanide man, who looks up the dosage. The estimator also empties the generators after the trees have been fumigated and should have a generator in

readiness when the chemical wagon drives up to a tree to be dosed. This procedure is followed until the entire row has been dosed. The three men then pass to the next row, having been preceded by the men who place the tents over the trees, and so on until the entire grove has been fumigated.

32. The cyanide should consist mostly of pieces that are an inch or an inch and a half across, but a few smaller pieces or even a small quantity of powder may be placed in the generator with the larger pieces. It is never advisable to have the whole dosage consist of small pieces and powder, for in such cases the action will be very violent, and some of the cyanide will be thrown out of the vessel and its effect lost, besides much damage will be done to the tent.

DISEASES OF CITRUS FRUITS

33. The term disease in its broadest sense applies to any condition that interferes with the normal growth and development of a tree; more specifically the term applies to any condition that results in the decay or death of any part of the tree—the roots, trunk, branches, leaves, or fruit. Some diseases result in a general debility of the whole tree without any very well marked symptoms. This is most apt to be the case when the disease is due to unfavorable moisture, food, light, temperature, or soil conditions. However, even when these are the causes, marked effects, such as the dying of certain parts, may result.

Many of the diseases are due to the attack of fungi and bacteria. Such diseases usually have well-marked symptoms by which each may be recognized. The usual symptoms are the dying of the roots and limbs, the spotting of the fruit and foliage, the formation of cankers or dead areas on the bark, the decay of fruits, etc. Fungi are very low forms of plants; many of them are useful in helping to break down organic matter into simpler forms for the use of plants as food, and some of them are parasites that are capable of entering the live tissue of plants and causing disease. The fungi are propagated

by means of invisible seed-like bodies known as spores, which may be carried by means of wind, insects, and birds. The cloud of dust formed when a fruit affected by blue mold is disturbed is made up of millions of these spores, each one invisible to the eye but in a mass appearing as dust. The spores germinate in favorable conditions of moisture and food material, and grow into a network of filaments or threads known as a mycelium. In many cases the mycelium is invisible inside the tissue of the plant, but in the case of the fungus root rot it is visible as a fan-shaped white growth under the bark. The mycelium gives rise to the spores again and so on over and over again from spore to mycelium.

In combating diseases preventive measures are most important and consist in removing the causes that operate in bringing on the diseases. It is, therefore, important to know first the cause or causes for any specific disease before attempting to remedy it. For most of the diseases discussed in the subsequent pages the causes are known, but there are others, the causes for which have not yet been found. The combating of fungous diseases consists: (1) in bringing about conditions, when possible, that are unfavorable for the development or infection of parasitic fungi; (2) in covering the parts of the tree with some preparation, as a spray, that will prevent the fungi from entering; (3) in pruning out the parts already infected and destroying them.

34. Gummosis.—Gummosis is a disease that is one of the most destructive forms of gumming of citrus trees. It principally attacks the lemon, although it occasionally attacks other citrus trees. The disease does not affect the roots or branches of the tree; it attacks the trunk, usually above the bud union, and causes an exudation of gum from cracks in the bark. When badly affected, the foliage of the tree becomes yellow and the tree is likely to die. Gummosis was formerly thought to be due to some deranged condition of the tree brought about by unfavorable soil, climatic, or cultural conditions. It has recently been discovered, however, by H. S. Fawcett, pathologist, at the University of California, that two

forms of gummosis are caused by fungi, the brown-rot fungus and the gray fungus, both well known as causing fruit rots on citrus fruit in the packing house.

The disease is most commonly found on trees that are planted on heavy, poorly drained, and poorly cultivated soils, especially if earth covers the bud union. Often the trunks of trees that stand in a slight depression where sediment is deposited about the base by irrigation water will be attacked. Such situations usually provide conditions that are favorable for the infection and growth of the fungi, especially the brown-rot fungus. It has been known for a long time that sour-orange trees are comparatively free from gummosis, whereas sweet-orange trees are frequently attacked. Experiments have shown that sour-orange trees are almost entirely resistant to the attack of these fungi, that lemons are least resistant, and that the sweet orange stands about half way between the sour orange and the lemon in resistance.

35. Both the brown-rot and the gray-fungus gummosis are characterized by a dying of the bark accompanied by an exudation of gum on the trunk about the point of infection. Fig. 31 shows the effect of gummosis on citrus trees. When these fungi do not occur together on the same tree, they show fairly well marked differences from each other. A tree infected with gummosis caused by brown rot has the bark killed through to the wood as fast as the infected area enlarges. The bark remains rather firm and later cracks longitudinally. There is also a peculiar odor suggestive of fresh paint. There is no evidence of fungus on the surface of the bark. Gummosis caused by the gray fungus has different symptoms. The bark is soft and mushy at first over a small area that is killed to the wood, and this smaller, soft area is surrounded by a larger infected area. The outer bark of this surrounding area is dead but the under bark is alive and active.

36. The prevention of gummosis caused by the brown-rot fungus consists in keeping the soil away from the bud union, avoiding excessive moisture about the crown of the tree, and planting trees that have been budded high on sour stock. For

situations where the conditions for infection cannot well be avoided, further protection to the trees can be secured by paint-

FIG. 31

ing the trunks of the trees with a concentrated Bordeaux mixture or Bordeaux paste.

Bordeaux paste can be made according to the following formula: 1 pound of bluestone, 2 pounds of unslaked lime, and 6 quarts of water. The bluestone should be dissolved

in 3 quarts of water, by suspending it in the water in a burlap sack so that impurities in the bluestone may not get in the solution; the lime should be slaked in 3 quarts of water. As soon as the slaked lime has cooled the two liquids should be stirred together, making a mixture about the consistency of whitewash. Bordeaux mixture should always be made in a wooden bucket. Apply the paste with a brush.

The trees should be inspected frequently and when the first sign of this disease appears the killed bark should be cut out and the entire trunk as well as the cut area painted with the Bordeaux paste. The earth about the base of the tree should be removed and the trunk painted with the paste down as far as the first crown roots.

37. Although preventive measures are of prime importance, trees having gummosis can often be treated successfully. The first consideration should be to improve the condition of the soil in the grove. If a plow sole has formed about the roots it should be broken up and the land thoroughly drained. If the land has been irrigated irregularly or too often, proper irrigation should be practiced. Often it is well to dig about the base of the tree and remove any hard, pasty, sour soil that may be found there, and replace it with gypsum mixed with river sand. This will improve the texture and correct the acidity of the soil, and also improve the drainage. Pruning out of some of the branches of the infected trees has been found effective. This makes a better balance between the top and the part of the trunk carrying sap.

38. Root Rot.—Root-rot disease is caused by a fungus that attacks many kinds of trees, including citrus, oaks, apples, walnuts, and many others. The names *fungus root rot*, *oak-fungus disease*, and *toadstool disease* are also used for this disease. The disease manifests itself by the appearance of clusters of light-brown toadstools about the base of the affected tree. In California, according to Professor Wm. T. Horne, of the University of California, these toadstools are found only in the late fall or the early winter. They are always seen growing on a decayed root or part of the tree below the ground,

and usually appear at the side of the tree, or encircling it. At times, however, they come up at a distance from the tree where a root comes near the surface of the ground. The toadstools produce spores which are often so abundant that they cover the ground as a white powder.

In addition to the toadstools, felty white growths spread out fanlike within the bark of affected trees. These growths crowd into the healthy bark, which puffs up, becomes moist, and often gummy. A white rot of the wood soon follows; this is accompanied by a clean mushroom odor. The fungus spreads from one place to another by black, cord-like strands about $\frac{1}{16}$ inch in diameter. These are known scientifically as *rhizomorphs*. Occasionally they fork, but they do not branch like roots. These strands attain enormous length. They may course upwards and downwards in the affected tree, generally under the bark or merely in close contact with the outer surface. They also grow through the soil to considerable distance and thus serve to spread the disease from one tree to another. From a small infected area in a grove the disease may spread for several years until quite a large area is affected. Frequently several affected areas in a grove overlap, and if growth is allowed to continue, the entire grove may be affected.

39. Control measures in an affected area consist in blasting out old roots and burning them and then planting some annual crop. After a period of years trees may again be planted, but there will usually be danger of the fungus being in the soil and affecting the new trees. The margin of an affected area should receive treatment to prevent the spread of the disease. A plan suggested by Professor Horne is to uproot a number of healthy trees in the zone of advancing infection in the hope of removing enough roots to prevent the fungus from passing through the soil. This work should be done thoroughly and all large roots removed from the cleared strip. Professor Horne reports further that he has been trying some experiments in endeavoring to isolate the affected trees by digging a trench around the trees deeper than the roots penetrate, lining the

side of this trench with tarred paper, and then refilling the trench in order that cultivation and irrigation can proceed as usual. The theory is that the paper will prevent the healthy roots from passing into the infected area. The success of this treatment is not yet assured on account of the short length of time it has been tried, but it is certainly worthy of trial.

Fig. 32 shows the toadstools of fungus root rot.

40. Maldigoma.—Maldigoma, or *foot rot*, is a disease that is rarely found in California, but it is very common in Florida. It is characterized by a decay of the bark at the

FIG. 32

surface of the ground and the exudation of gum on the trunk just above the soil. The bark and finally the wood becomes rotten and dead and a disagreeable, fetid odor is present. Although the dead areas spread in all directions, they spread most rapidly down the main crown roots and around the trunk near the ground. Leaves on affected trees become yellow, the twigs and young branches die, and the tree puts forth a heavy crop of fruit. The entire tree assumes a very unthrifty appearance.

The disease is generally found on trees growing on wet, heavy soils where too much water is allowed to stand about

the base of the tree. Preventive measures against this disease consist in planting trees that have been budded on sour stock. The remedy after a tree is attacked by the disease is to dig up the soil about the base of the tree and after removing the diseased parts, disinfect the wounds. In Florida, strong, thick Bordeaux mixture applied with a brush has been found to be satisfactory for this purpose. The instrument used for cutting the diseased parts should also be disinfected.

41. Exanthema.—Exanthema, or *Florida die-back*, is a disease caused by improper fertilization. The branches die back from the ends and the bushy tufts of small twigs form all through the top of the tree. In addition, corky outgrowths form on the bark of twigs and from these outgrowths gum exudes. About the first symptoms of the disease is the development near the center of the tree of oversized dark green leaves. The fruit becomes a pale yellow color while still small, and as it matures it fails to develop much acidity and is insipid to the taste. The rind becomes marked with characteristic brown or black spots, which vary in size from $\frac{1}{16}$ inch to patches covering the whole fruit. The fruit splits easily, and usually through the spots. Fig. 33 shows fruit spotted and cracked by reason of this disease.

In California, the disease is found most often in groves planted on coarse, gravelly soils, or on soils underlaid by gravelly subsoils that have been heavily fertilized with stable manure or some form of organic commercial fertilizer such as tankage or cottonseed meal. The disease is most likely to occur if the trees have been suffering for the want of plant-food and have been alternately too wet and too dry through improper irrigation practices. The remedy is to keep up the plant-food supply in the soil, and irrigate in a manner to maintain the moisture of the soil about uniform.

42. Trunk Rot.—What is known as trunk rot often occurs on citrus trees where the trunk or large limbs have been injured or where large limbs have been cut off in pruning. Decay of these wounded areas is accompanied by the production of small white bracket toadstools on the rotten wood. These

FIG. 33

toadstools are not parasites on sound trees as in the case of the fungus root-rot. The remedy is to cut out the rotten wood and protect the wound with asphalt paint, grafting wax, or some other wound dressing.

43. Chlorosis and Mottled Leaf.—Chlorosis and mottled leaf are terms that refer to a yellowing of the leaves. The term chlorosis is generally used when the whole leaf turns yellow and pale in color; the term mottled leaf is used when the leaves show a yellowing between the veins and midribs. However, some growers use the term chlorosis when referring to either case. In addition to the leaves turning yellow, the tree bears small crops of fruit and in some cases the fruit becomes yellow when only an inch or so in diameter. The yellowing of the leaves is due to the non-development or the slow development of chlorophyll, which is the green coloring matter in the leaves. The yellowing is not a specific disease, but the result of conditions that are unfavorable for the growth of the tree. Irregular supplies of moisture and plant-food are thought to be conditions favorable for the development of chlorosis and mottled leaf. Recent experiments show, also, that a particular kind of nematode worm that works on the roots is associated with this condition of the trees. As a rule, unless unfavorable weather conditions prevail, the yellowing can be controlled by keeping the soil in proper physical condition and practicing proper fertilizing and irrigating methods. It is especially important that any hardpan that forms below the plane of deepest cultivation be broken up.

FIG. 34

44. Scaly Bark.—In California what is known as scaly bark, or *psorosis*, is a disease that is characterized by the bark being pushed up and broken into pieces, over areas varying in size from an inch to a foot or more in length. In Fig. 34 is shown an orange limb affected with this disease. The infected areas are often shaggy and ulcerated in appearance and may extend around the trunk or a large limb. During the growing period drops of gum exude, but gumming usually ceases during the fall and winter. The affected portions soon spread and diseased limbs die back slowly, but new wood keeps taking their place. A tree may live in this unhealthy condition for a number of years. This disease occurs most commonly on orange trees and only occasionally on grapefruit trees.

The exact cause of scaly bark is not known, but it is probably due to improper irrigation. The remedies advised by the University of California are: (1) Dig out and replace the worst affected trees; (2) remove diseased branches in trees only partly affected; (3) in case of small affected areas on the trunk, scrape off the scaly bark and cut out the diseased portion to healthy wood and cover and paint the wound; (4) if the trunk is badly affected but the tree fairly healthy, scrape off the loose bark and paint with Bordeaux paste.

45. Twig Blight.—The disease known as twig blight, although it is not at all serious, sometimes occurs on citrus trees in California in moist weather. Trees are infected from spores produced by the fungus growing on cover crops in the grove. The twigs on affected trees die back from the tip and often show on their surface a white moldy fungus in which there may be imbedded small, hard, seed-like bodies that are at first white but finally become black. A mass of gum exudes at this point. Twig blight is produced by the same fungus that causes the cottony rot of fruit.

46. Withertip.—Withertip is a term which has been applied to the effects of a fungus on the tips of small branches causing them to wither and die. It may be found on trees of all ages, affecting and killing back the tips of the branches.

On large trees this prevents the setting of a heavy crop of fruit. The disease is easily distinguished from exanthema, or die-back, by the ashen color of the twigs, whereas die-back produces a brown effect on the twigs; by the line or ring separating injured tissue from healthy tissue, which is absent in the die-back disease, and by the frost-like killing of the twigs.

The disease was first described in Florida, where it is very common and where it often does much damage. In California the withertip fungus appears to be less serious than in Florida. The fungus also manifests itself on the fruit in a manner known as tear staining and in California in some seasons this disease on the fruit is very common. Tear staining is characterized by a brownish or dark-reddish stain on the outer surface of the rind. Accompanying this sometimes are small reddish-colored pits, which sometimes thickly cover the surface of fruit, especially lemons. There also occurs larger dark-red somewhat sunken spots on the fruit in which the withertip fungus is found. These are known as anthracnose spots.

Tear staining and red pitting of the fruit may be prevented by frequent spraying with lime-sulphur or Bordeaux mixture.

47. Damping Off.—Young seedling citrus trees in the nursery are often affected by a disease known as damping off. This disease is caused by a fungus that is in the soil. The effect of this fungus, if it is present, may be seen on the seedlings a few days after germination. The point of attack is just below the surface of the ground. The tissues of the seedlings collapse at the surface of the ground and they fall prostrate on the ground.

The disease may be prevented by not allowing the soil to become too wet and by keeping the surface of the soil stirred. The seedlings should stand far enough apart in the seed-bed in order that air may circulate freely among the plants. Some protection may also be secured by spraying the plants as they come through the soil with ammonical solution of copper carbonate, 5 ounces of copper carbonate, 3 pints of ammonia of 26 degrees strength, to 50 gallons of water.

48. Black Pit.—Black pit is a disease of minor importance that is sometimes found on lemons that are overripe. It is not considered a serious disease and usually affects only a small percentage of fruit. It most often occurs on what are known as tree-ripe lemons and has been found in only a few sections of Southern California. It has been shown by C. O. Smith, of the University of California, to be due to a bacterium that is thought to gain entrance through slight injuries in the skin. The disease manifests itself on the fruit by a pronounced sinking of the rind, resulting in a very dark brown to black

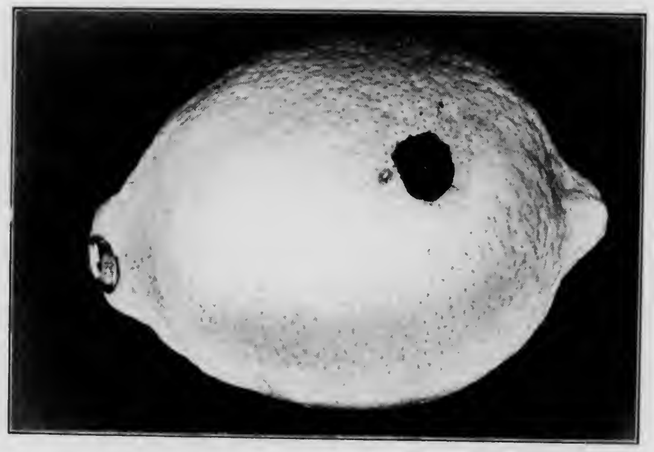


FIG. 35

depression $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter. Fig. 35 gives a good idea of the way fruit is affected by black pit.

49. Cottony Mold, or White Rot.—Lemons in the curing house are frequently subject to a disease known as cottony mold. An abundant growth of white mold, as illustrated in Fig. 36, spreads over the lemons, in which are found black seed-like bodies from which another stage of the fungus causing the disease develops. The fruit finally decays. The fungus causing the cottony mold also develops in the soil of the grove during the rainy season and often becomes very abundant on green manure crops or on other vegetation growing about lemon trees. It grows particularly well on vetch. The fungus seems to require much moisture for development and

for this reason is troublesome during wet years. Spores of the fungi pass from the soil and vegetation of the grove to the lemons and when conditions are favorable, such as plenty of moisture or a wound in the fruit, the spores germinate and grow and produce the cottony mold disease. Lemons that are allowed to stand outdoors during wet weather after being picked often become infected. The disease, however, is most largely spread in the wash water when lemons are washed before being packed. The spores find their way into the wash water and it seems that the bluestone solution in which lemons are washed to kill the brown-rot fungus serves as a means of

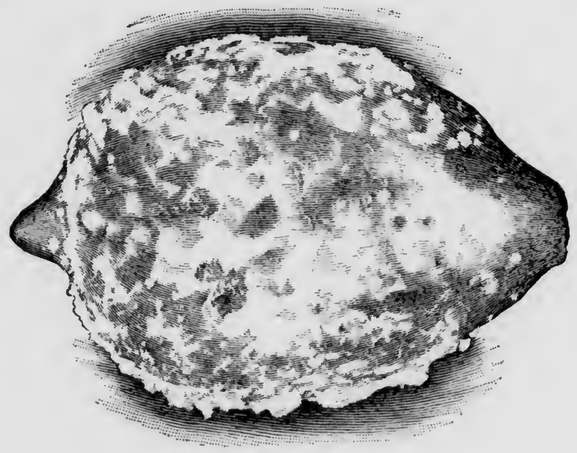


FIG. 36

disseminating the spores of the cottony mold fungus. When the fruits become bruised or scratched infection results. The solution is not strong enough to kill the spores of the cottony mold fungus, and if the solution were made sufficiently strong to kill these spores it would be dangerous to use it for this purpose.

When the disease becomes prevalent in a grove it would perhaps be best to give up the use of vetch as a cover crop for a few years.

50. Brown Rot.—Brown rot is a disease that affects citrus fruit while still on the tree and also after the fruit is picked. The disease is often seen on the fruit on the tree in wet weather

and is mostly confined to fruit that is within several feet of the ground. Brown rot spreads rapidly and is more often found on lemons than on oranges and is especially troublesome on lemons that are held in storage for curing. The disease manifests itself as a brown, rather dry decay of the rind. In boxes, if much moisture is present, there appears above the decayed portion, a delicate white scanty mold; on fruit in the open no mold appears. Fruit affected with this disease has a peculiar characteristic odor that is easily recognized.

The fungus that causes the brown rot lives primarily in the soil, under the trees, where its spores are produced. For this reason preventive measures consist in keeping the trees pruned up from the ground, cultivating the soil under the trees in summer, and covering the soil in winter with straw or planting a cover crop. Much brown rot infection is spread by washing the lemons in a tank before they are packed. It has been found that much of the spreading can be prevented by placing copper sulphate, which is a fungicide, in the wash water. The quantity recommended is 1 to $1\frac{1}{2}$ pounds to each 1,000 gallons of water. The fungus causing the brown rot also causes the brown-rot form of gummosis which has been discussed in a preceding paragraph.

51. Blue Mold and Green Mold.—Blue mold and green mold are generally the cause of decay in citrus fruit. The blue mold is more active than the green mold and sometimes causes infection by contact from one fruit to another. Affected fruit shows a soft mold decay, the surface of the infected area being covered with a dusty mass of spores that are blue in color if the blue mold is present or green in color if the green mold is present. Fig. 37 shows an orange affected with blue mold.

Experiments carried on by the United States Department of Agriculture have demonstrated that the decay from mold is confined entirely to fruit that is bruised or otherwise injured in handling. Therefore, growers and packing-house employes should take precautions to avoid making cuts when clipping the fruit from the tree, and bruises from rough handling when

hauling the fruit to the packing house and in all grading and other packing-house operations. Formerly much California fruit was lost by decay in transit, but in recent years more careful handling has been practiced and as a result there is very little fruit lost in transit.

52. Gray Mold.—Gray-mold fungus produces a dark-colored decay of the rind of lemons, and on this decay a dirty gray mold forms. The fungus can develop at temperatures close to freezing and occasionally causes loss in fruit in cold

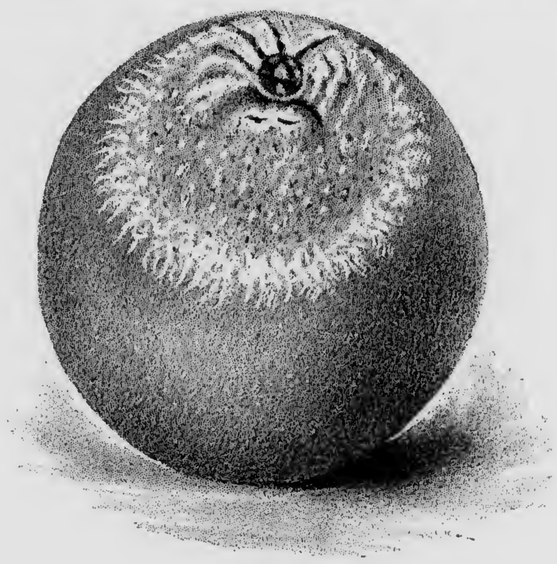


FIG. 37

storage, but usually it is not considered to be a serious trouble. Fortunately it usually develops only on weak fruits that have been injured or are overripe and is sometimes found on fruits that have been only slightly injured by frost. This is the same fungus that may cause one of the forms of lemon gummosis.

53. Black Rot.—Occasionally in seasons of heavy early rainfall a disease known as black rot, or *navel rot*, becomes rather abundant, but usually the trouble is not serious. It is navel oranges that are affected; they color prematurely in

the fall, and there develops a dry black rot in the tissues at the navel end. The rot does not spread very rapidly and often remains confined to one section of the orange. Fig. 38 illustrates an orange affected with black rot. The loss is usually not very great, rarely exceeding 5 per cent. of the crop.

54. Red Rot.—Red rot is a disease that is frequently found on lemons in the curing house. The rind of the lemon becomes a bronze, rusty color and gradually dries, leaving a sunken area on the fruit. The sunken area is dark red in color or sometimes black. The true cause of the disease is unknown, but it is thought by some to be associated with slight sun burning and by others to be due to a weakness of the fruit caused by an improper condition of growth at the time the fruit is forming.

FIG. 38

55. Puffing.—Some years oranges are affected by a puffing of the rind of the fruit. The surface becomes rough and uneven, the skin is spongy, and the whole orange is soft, structureless, and unnaturally sweet. The trouble varies in different years, and is thought to be due to unfavorable moisture conditions.

56. Splitting.—Citrus fruit, especially oranges, sometimes crack and split while hanging on the tree before becoming mature. This is apparently caused by seasonal conditions that produce irregular growth. This trouble will vary from year to year, depending on the season. One cause for splitting is dry, hot weather, which causes the rind to set before the fruit has grown to proper size, followed by moist, favorable growing weather, which causes sufficient pressure inside the developing fruit to split the rind.

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57. Leaf Spot.—Leaf spot is a minor trouble that is not at all serious. It is characterized by the appearance of a dark-colored slightly raised spot on the back of leaves exposed to the sun. The spots are caused by a gum that appears to be the result of sunburn.

58. Citrus Galls.—Gall-like swellings sometimes occur on the branches of citrus trees and occasionally these are found by the pruner. They are thought to be due in California to the same bacterium that causes crown gall in peach and other fruit trees. They appear to be of no serious consequence on citrus trees, but should be cut out and burned whenever found.

CITRUS FRUITS IN GULF-COAST STATES

(PART 1)

GENERAL MATTER

1. Citrus Sections.—The growing of citrus fruits in the southeastern part of the United States is, on account of climatic conditions, confined to certain sections in Florida, Alabama, Louisiana, Mississippi, and Texas, but by far the largest of these citrus-producing sections is in Florida. For convenience in referring to the different citrus sections of Florida, the Florida State Horticultural Society has divided the state into four distinct sections, which are known as Western North Florida, Eastern North Florida, Central Florida, and South Florida. The Western North Florida section is west of the Aucilla River. The Eastern North Florida section is that part of the state between the Aucilla River and a straight line drawn across the state from the mouth of the St. Johns River to Cedar Keys. The Central Florida section is that part of the state between the line above referred to and the counties constituting South Florida. The South Florida section includes the counties of Brevard, St. Lucie, Palm Beach, Lee, Dade, Monroe, DeSota, and Manatee. In Central and South Florida a large part of the cultivated land is planted with citrus trees and the production of citrus fruit is of great commercial importance. In both Western and Eastern North Florida, citrus growing is of somewhat less commercial importance, but, nevertheless, many citrus groves are found scattered over these parts of the state.

2. In Alabama, Mobile and Baldwin counties have several bearing groves of oranges, principally of the Satsuma variety budded on *Citrus trifoliata* roots, which, as will be learned later, makes a fairly hardy tree. Many authorities claim that the prospects for the culture of this variety in the southern part of Alabama are very promising, and, as a result, numerous new groves are being planted.

3. In Mississippi, citrus fruits are grown most extensively in Jackson, Harrison, and Hancock counties, which border on the gulf. In this section many groves have come into bearing recently, and, as a result, the industry is assuming considerable commercial importance. Previous to 1907 most of the fruit was consumed locally.

4. Most of the citrus groves in Louisiana are in Plaquemines Parish. Small groves are found also near Lake Charles in St. Mary's Parish, and just below New Orleans in St. Bernard's Parish.

5. In Texas, small groves are scattered here and there over a large part of the territory bordering on the gulf. The attempt to grow citrus fruits in the Texas gulf-coast region is of recent date. From 1899 to 1910 the winters were very mild and it was during this period that the industry began to assume the aspect of commercial importance. Since 1910, however, there have been periods of low temperatures which have had the effect of retarding the planting of trees in sections where the temperature dropped low enough to injure the trees. Nevertheless, some parts of Texas seem favorably adapted to citrus production, and in time the industry is likely to become important commercially.

6. Kinds of Citrus Fruits Grown in the Gulf-Coast Sections.—The principal citrus fruits grown in the gulf-coast sections are sweet oranges, grapefruits, or pomelos, and Mandarin oranges. Of the three, the sweet oranges are the most largely planted; grapefruit ranks second in importance, and Mandarin oranges third.

Lemons are not grown commercially to any extent in the gulf-coast states; the small amount of fruit raised is largely consumed locally. Citrons and shaddocks are grown only for ornamental purposes or as novelties.

Limes are not extensively grown on the mainland, but on some of the keys in the southern part of Florida many trees are found. Here they grow like native trees without cultivation. These wild limes, known generally as Key limes, are small and contain many seeds, but there is a market demand for them and they bring good prices. Trees of the same variety grown under cultivation produce larger fruits, but they are not so much in demand. Budded limes behave in the same way. A number of varieties are offered for sale by nurserymen.

Kumquats are grown to some extent in Florida, the trees usually being grown in a grove with orange and grapefruit trees. Kumquats are usually packed in display boxes with fancy oranges and grapefruit, but sometimes they are packed in separate boxes.

In the other citrus-producing states of the gulf coast, a few varieties of sweet oranges, Mandarin oranges, and grapefruit are planted, but the most largely planted variety of citrus fruit, except perhaps in Louisiana, is the Satsuma orange budded on Citrus trifoliata stock. Kumquats and grapefruit are also grown to a limited extent in these states.

7. Prospects of the Citrus Industry.—In certain parts of Florida and in a few places in the other gulf-coast states, large plantings of citrus trees are being made and some of the groves, both old and new, are receiving good care. This means, provided, there is no loss of trees on account of frost, that there will be, in a few years, a large acreage of bearing citrus trees. There is, however, always the liability of loss by frost, which means a reduction both in the number of bearing trees and in the quantity of citrus fruit produced. In addition, many groves have been, and will continue to be, planted on unfavorable sites, and as is always the case in fruit culture, many groves will not receive proper care and attention. Such groves never yield profitable crops. But when these unprofitable

groves are compared with the new groves that have been planted and that get proper care, it appears that there will soon be an increase in the quantities of citrus fruit produced in the Southern States. The consumption of citrus fruit is also on the increase, and it is thought that the increased consumption will take care of the increased output. As with all kinds of fruit, first-class oranges and grapefruit will probably never go begging for a profitable market, and provided this kind of fruit is produced, there seems every indication that the growers in favored localities in the gulf-coast states will be successful. If, on the contrary, inferior fruit is produced, the results will not be satisfactory.

8. The profits from citrus fruit groves are generally very good, provided the grove is situated in a desirable location and receives proper attention. When considering profits in citrus culture, it should always be remembered that the growing of citrus fruits is a business that requires much capital, abundant knowledge of fruit culture, and close attention to details. In this respect, it is interesting to quote from Prof. P. H. Rolfs, Director of the Agricultural Experiment Station of Florida, who says in a United States Department of Agriculture Bulletin:

> The growing of the finest citrus fruits is a horticultural accomplishment not surpassed in any line of industry. There are very few agricultural occupations that require an equal amount of judgment and very few that give as remunerative a return for the mental outlay. Every one who is willing to pay the price, either in labor or in dollars, can grow oranges and grapefruit, but only he who is so constituted as to derive pleasure from exercising his mental faculties to their fullest extent can produce fruit of the finest quality. There is a very long series of conditions, from the choice of the site to the delivery of the package of perfect fruit to the consumer, which must be met successfully. If any link in the chain is broken, first place cannot be attained. Good judgment must be exercised in the choice of the stock, the bud, the soil, and the location of the crop, in the treatment of fungus and insect diseases, in picking and packing the fruit, and in selecting a market for its disposal.

9. Size of Groves.—The groves vary in size from those containing a few trees on city lots to those of 1,000 acres or more. For a person starting in the business, a 10-acre grove,

or in some instances even one of 5 acres, will contain enough trees to care for until experience in the management of groves has been obtained. After the trees come into bearing the profits should be sufficient to give a good income. The usual equipment for a 10-acre grove includes a team, a plow, a harrow, a spraying outfit, a pruning outfit, a mower and hay rake, fruit-harvesting appliances, and, in some sections that are dry during certain seasons of the year, an irrigation system. With a little additional help at busy seasons, a man and team can care for a 20-acre tract, but there is always the likelihood that the larger area will not be taken care of so well as the smaller area; hence, the reason for advising a 10-acre unit when first starting in the business.

VARIETIES OF CITRUS FRUIT

VARIETIES OF ORANGES

10. The number of varieties of oranges that can be grown in Florida is very large, but only varieties such as have proved their value commercially are planted by commercial growers. The time of ripening is one of the most important factors that determines the commercial value of a variety. According to the time of ripening, the different varieties may be classified as early, midseason, and late. Many of the varieties grown are excellent in quality, flavor, and prolificness, but they have the disadvantage of being in season just at the time when the market is well supplied with oranges from some other citrus section. The varieties that mature at such a season are often less desirable for planting than other varieties that mature and can be placed on the market when there is little competition with oranges from other sections.

11. The principal commercial varieties of oranges now being planted in Florida are Parson Brown, Homosassa, Pineapple, Hart's Late, Valencia Late, and Lue Gim Gong. Of the Mandarin group of oranges, the Dancy Tangerine and the King

are the most largely planted in South Florida. However, in the northern part of the state, the Satsuma is grown to some extent.

Along the gulf-coast sections of Northern Florida, and in Alabama, Mississippi, Louisiana, and Texas, the Satsuma, Parson Brown, and Pineapple are the favorite varieties of oranges. The Nagami is the favorite variety of kumquat in these sections.

Although the varieties just mentioned are most important commercially in certain sections, the other varieties described in the subsequent paragraphs are very important in the home grove and should not be lost sight of entirely. The varieties of citrus fruits described in the subsequent paragraphs are arranged somewhat according to their season of ripening, but no attempt has been made to classify them otherwise.

12. The **Boone,** or *Boone's Early,* is one of the very early varieties of oranges grown in Florida. The fruit is of medium size, rounded in form, and deep yellow in color. The quality is fair, with the acid characteristic not strongly developed. The season is from the first or middle of October to about the last of November. The fruit drops badly as soon as it becomes ripe, and for this reason it should be picked as soon as it is colored enough to ship. This variety is grown commercially to some extent in sections where a very early orange develops well and fits into the regular marketing scheme of the locality.

13. The **Sweet Seville** is another very early orange that meets with favor by some Florida growers, although it is not an important commercial variety. The size is medium, the form round, and the flavor is distinctly sweet. It keeps and ships well, and often commands a fair price on the market. The trees are vigorous and prolific.

14. The **Satsuma** orange is a member of the Mandarin, or tangerine, group that has met with favor in some districts of Northern Florida and in the citrus-producing districts of the other gulf-coast states. The oranges are flattened in form,

and the sections frequently show through the rind. The size is variable, ranging from $1\frac{7}{8}$ to $2\frac{5}{8}$ inches in the short diameter to $2\frac{5}{8}$ to $3\frac{7}{16}$ inches in the long, or transverse, diameter. The color is orange yellow; the rind parts easily from the pulp, and the sections part easily from each other, as may be seen in Fig. 1, which illustrates a group of Satsuma oranges. The flavor is very agreeable, being sprightly and characteristic of Mandarin oranges.

The tree is thornless, of a dwarf, spreading habit, and will withstand without injury a considerable degree of cold. For

FIG. 1

this reason, the Satsuma is recommended as a commercial variety for districts subject to low temperatures. In the extreme southern part of Florida, the Satsuma is of practically no value, because the fruit does not color well; it remains green after the juice has acquired its best flavor. In favorable situations, the trees come into bearing early and are very prolific. It is one of the early varieties, the season being during October and November.

In Fig. 2 is shown a part of a tree with fruit on it. The flattened character of the fruit and something of the prolificness of the tree can be seen in the illustration.

15. The **Centennial** is an early variety of the sweet

FIG. 2

orange, and has many good qualities. The fruit is rounded in form, from small to medium in size, and of an orange color. The quality is good and the flavor is rich and vinous. The

fruit ripens early, but hangs to the tree well, and retains its quality until late in the season. The trees are vigorous and prolific. The season is from November to December.

FIG. 3

16. The **Nonpareil** is an early variety that is grown to some extent in Florida, and has many good qualities. The fruit is roundish, from medium to large in size, and varies from

yellowish to orange in color. The quality is excellent, the acidity and sweetness being well blended. The trees are vigorous and prolific. The variety originated as a seedling in Florida. The season is from December to January.

17. The **Parson Brown** is one of the best of the early varieties of oranges and is the principal early commercial variety grown in Florida. It originated in the grove of Parson Brown, at Webster, Florida; hence the name. The orange is somewhat oblong in form, medium to large in size, and from yellow to yellowish orange in color. The peel is smooth and

FIG. 4

has a fine texture. The quality is good and the acidity and sweetness are well blended if the orange is picked early, although the sweetness slightly predominates. The Parson Brown is one of the few oranges that is green in color when it is ripe. It begins to ripen about October and continues on into November. It keeps and ships well.

A branch of a tree of the Parson Brown variety is shown in Fig. 3. The oblong form of the orange can be seen in the lower part of the illustration. The fine texture of the peel is also apparent.

18. The **Homosassa** variety of orange is usually roundish, but sometimes slightly flattened; it is medium to large in size and from yellow to orange yellow in color. The skin is bright, smooth, thin, and tough. The flesh is rather coarse grained; the quality is excellent, the flavor vinous and sprightly, and the acidity and sweetness are well blended. The fruit keeps and ships well. The oranges ripen in midseason, which is from December to February. The tree is vigorous and prolific.

FIG. 5

A fruiting branch of the Homosassa variety is shown in Fig. 4. The roundish form of the orange is very apparent in the illustration.

19. The **Jaffa** orange is a variety of excellent quality; in fact, it is one of the best of the midseason varieties. The fruit is generally round and slightly flattened in form, but occasionally it is oblong. Both shapes are shown in Fig. 5, which illustrates a fruiting branch of a tree of this variety. The

orange of this variety is from medium to large in size, and in color from orange yellow to orange red. The peel is thin and leathery; the pulp is very free from fiber, and is rich, juicy, and of excellent flavor. The fruit, although ripe in midseason, remains on the tree for a long time after ripening. The season is from December to February, or often longer. The tree is a

FIG. 6

strong, upright grower, practically thornless, and prolific when mature.

20. The **Madam Vinous** is a variety that originated as a seedling in the Indian River section of Florida. The fruit is roundish and slightly flattened in form; it may be small, medium, or large in size; the color is orange. The quality is very fine, the juice plentiful, and the sweetness is well blended with the acid. The fruit ripens in midseason, which is during December and January. The trees are strong and vigorous.

FIG. 7

21. The **Magnum Bonum** is a large, flattened variety of orange; it has an orange-yellow color and a smooth, glossy skin. The flavor is sweet and rich, and the quality excellent. The pulp is fine grained and has abundant juice. The oranges are good shippers. The season is from about the first of December to the middle of February. The trees are prolific and vigorous.

FIG. 8

22. The **Majorca** variety of orange is so called because it was imported from the island of Majorca. The orange is generally rounded but sometimes slightly flattened; it is small to medium in size and of a rich orange color. The flesh is fine grained, and has abundant juice. In quality the orange is

equal to the Jaffa; it keeps and ships well. The tree is a strong, robust, bushy grower, nearly thornless, and bears exceedingly well. The season is during February and March. The general shape of the fruit can be seen in Fig. 6, which shows a branch of fruit of this variety.

23. The **Old Vini** variety of orange, which is known also as *Beach's No. 4* and as *Buena Vista*, is a seedling variety that originated at Orange Mills, Florida. The fruit is slightly flattened in form, from medium to large in size, and orange in color. The rind is smooth, tough, and leathery; the flesh is coarse; and the juice is abundant. The flavor is good and the fruit ships well. The variety is in season during December, January, and February. Fruit of this variety is shown on a branch in Fig. 7.

24. The **Pineapple** orange is one of the best midseason varieties grown in Florida and is recommended for extensive plantings; in fact, it is one of the most desirable commercial oranges produced in Florida. The fruit is variable in form, some specimens being nearly round and others distinctly flattened. In size it is from medium to large and in color a deep orange, full, ripe, well-colored specimens sometimes showing a reddish tinge. The peel is thin but tough, and is very smooth and bright. The orange is heavy, juicy, and of excellent quality, and it keeps and ships well. The season is January and February, although the oranges hang well to the trees and can often be held until later in the season. Shipments of first-class fruit have been made as late as April and May. The tree is a strong, upright grower and is very prolific. A fruiting branch of a Pineapple tree is shown in Fig. 8, which gives a good idea of the characteristic form and the smooth, bright appearance of the peel.

25. The **Ruby,** a blood variety of the sweet orange, is the best of this type grown in Florida, and for those who desire to grow blood oranges it is the one recommended for planting. The form is round or slightly oblong; in size it is small to medium, and in color a deep orange that becomes reddish when

fully matured. The rind is smooth, shiny, and tough. The pulp is rich, juicy, and of excellent flavor, and as the fruit ripens the pulp becomes streaked with red. When fully mature, the pulp is distinctly red. The fruit keeps and ships well and commands a good price on the market. The trees grow vigor-

FIG. 9

ously, bear regularly, and are nearly thornless. The season is February and March. Fig. 9 shows a group of Florida-grown Ruby oranges.

26. The **Enterprise,** or *Starke Seedless*, orange is somewhat oblong in form and medium to large in size. The color ranges from yellow to orange. The flesh is orange in color, coarse, and has abundant juice. The acidity and sweetness are well blended, which gives the orange a fine flavor. The

quality is very good. As indicated by the name, it has few or no seeds. The Enterprise is an early variety, ripening in October and November. The variety is named after the town of Enterprise, Florida. The tree is vigorous and productive. A fruiting branch is shown in Fig. 10.

FIG. 10

27. The **Hart** variety of orange is sometimes known as *Hart's Late* and also as *Hart's Tardiff*. The latter name is derived from the Spanish word tardeo, meaning late. The fruit is round or slightly oval in form, of medium size, and of a deep golden-orange color. The rind is thin, smooth, and tough.

The quality and flavor are very good. The Hart is the most largely planted late variety of orange in Florida. The variety has several characteristics besides quality that make it especially valuable for commercial plantings, for which it is recommended. As the name indicates, the season is late. It ripens in April, but may hang on the tree during May into June without deterioration. This permits it to be brought on the market when there is practically no competition with other oranges

FIG. 11

from Florida or California, the California Valencias not being ready to ship when the Hart is on the market. For this reason it generally brings a good price. It also ships and keeps well, which is very important for a commercial variety of orange. By many this variety is considered to be the same as the Valencia, and shipments are often made under that name.

28. The **Dancy,** or *Dancy Tangerine*, is the principal orange of the Mandarin group grown in Florida. The fruit is flattened

in form and small, averaging from $1\frac{3}{4}$ to 2 inches in axial diameter and from $2\frac{5}{8}$ to 3 inches in transverse diameter. The color is a deep orange red; the skin separates readily from the flesh, and the segments, as in all Mandarin oranges, separate readily from each other. The orange contains from seven to twenty seeds. The pulp is dark orange in color, rather coarse, juicy, aromatic, and of a rich flavor. In Florida and in most markets the variety is known simply as the tangerine. The season is December and January. The tree is compactly

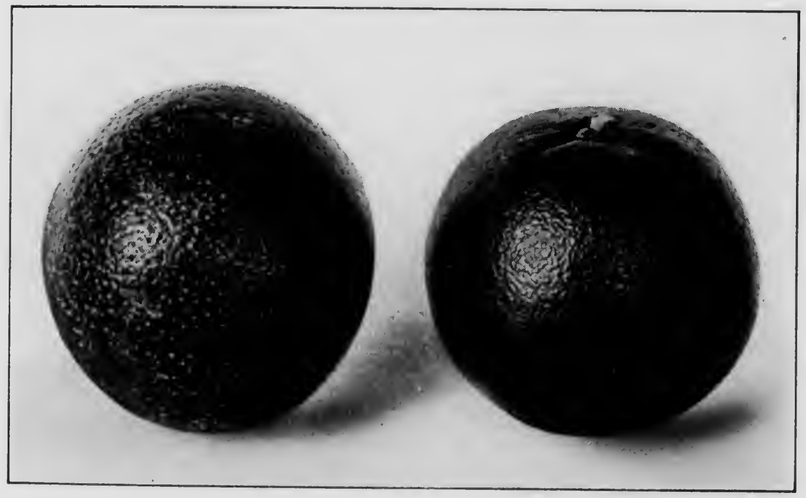

FIG. 12

headed, rather upright in growth, but tends to spread, due to the weight of the fruit. A branch of a tree of this variety is shown in Fig. 11.

29. The **King,** *King of Siam*, or *King Tangerine*, is the largest of the Mandarin oranges. It is flattened in form and of large size, averaging about 3 inches in axial diameter and $3\frac{3}{4}$ inches in transverse diameter; the color is deep orange. The skin is exceedingly rough, nevertheless the appearance of the fruit is very attractive. The pulp is juicy, meaty, of excellent flavor, and, as in the Satsuma and Dancy oranges, the skin separates readily from the pulp segments. The tree is prolific and an upright grower, but the wood is brittle and easily

broken. The season is March, April, and May, but the oranges keep in good condition even later. In the central and southern parts of Florida the variety is not much desired by growers, but in some parts of the eastern section, notably in the Halifax and Indian River districts, it is much prized. The fruit is in demand and always brings a good price on the market.

30. The **Valencia,** or *Valencia Late*, is a late variety that is very important commercially in Florida. The fruit is slightly oval in form, medium in size, and light orange in color. The peel is smooth, rather thin, and of a strong texture. The flesh is firm, crisp, juicy, and of fine grain. The orange has abundant juice, an excellent flavor, and but few seeds. The fruit ripens at about the same time and has practically the same market possibilities as the Hart. The tree is a rapid grower and very prolific. In districts where there is no danger of frosts, the crop can be allowed to hang on the tree for some time after it is ripe. Fig. 12 shows two Florida-grown Valencia Late oranges. The smooth peel and oblong shape are well shown in the picture.

31. The **Lue Gim Gong** orange is a late variety of recent origin that promises well for Florida conditions. Its greatest value is due to the fact that fruit hangs on the tree until late in the summer or even longer, thus making it possible to sell it whenever the market is right. The variety was originated by Lue Gim Gong, of De Land, Florida, and is supposed to be a cross between Hart's Late and the Mediterranean Sweet. The fruit is oblong in form, as shown in Fig. 13, medium to large in size, and deep orange red in color. The peel is thin and smooth, the quality is good, and the flavor a blending of sweet and subacid. It ships and keeps well. The trees seem hardy and resistant to cold. Many prominent horticulturists and growers of Florida deem the variety exceptionally worthy of extended trial. The variety was first distributed by the Glen Saint Mary's Nursery Company, of Glen Saint Mary, Florida, and is thought to be a very valuable addition to the list of commercial oranges for Florida conditions.

FIG. 13

32. The kumquat group consists of two principal varieties, the *Nagami*, or oblong, and the *Marumi*, or round. The kumquat is native to China. The name kumquat is from the Chinese, and means gold orange. The kumquat is grown to some extent in Japan, in which country it is known as the Kin-Kan, which is the Japanese equivalent of gold orange.

FIG. 14

33. The tree of the **Nagami** is a bush 8 to 12 feet high; it has dark-green, glossy lanceolate leaves. The fruit is small in size, being on an average about $1\frac{1}{2}$ inches through the apex and about 1 inch in transverse diameter. The color is golden yellow; the rind is smooth, aromatic, and spicy; the juice is acid and rather sparse; the seeds number from two to five. The season in Florida is from October to January. The whole fruit, rind and pulp, is generally eaten raw. A cluster of this variety is shown in Fig. 14.

34. The tree of the **Marumi** variety is similar to that of the Nagami, except that it is slightly more thorny and the leaves are somewhat smaller and rounder at the apex. The fruit is spherical, averaging from about 1 inch to $1\frac{1}{4}$ inches in diameter. The rind is thin and spicy and there is a sparse pulp, as in the oblong variety. The season is 2 to 3 weeks earlier than the season of the Nagami.

VARIETIES OF GRAPEFRUIT

35. Many budded varieties of grapefruit are offered for sale by nurserymen, but growers do not pay as much attention to varietal differences in grapefruit as to those in oranges. The reason for this is that many grapefruit trees are grown

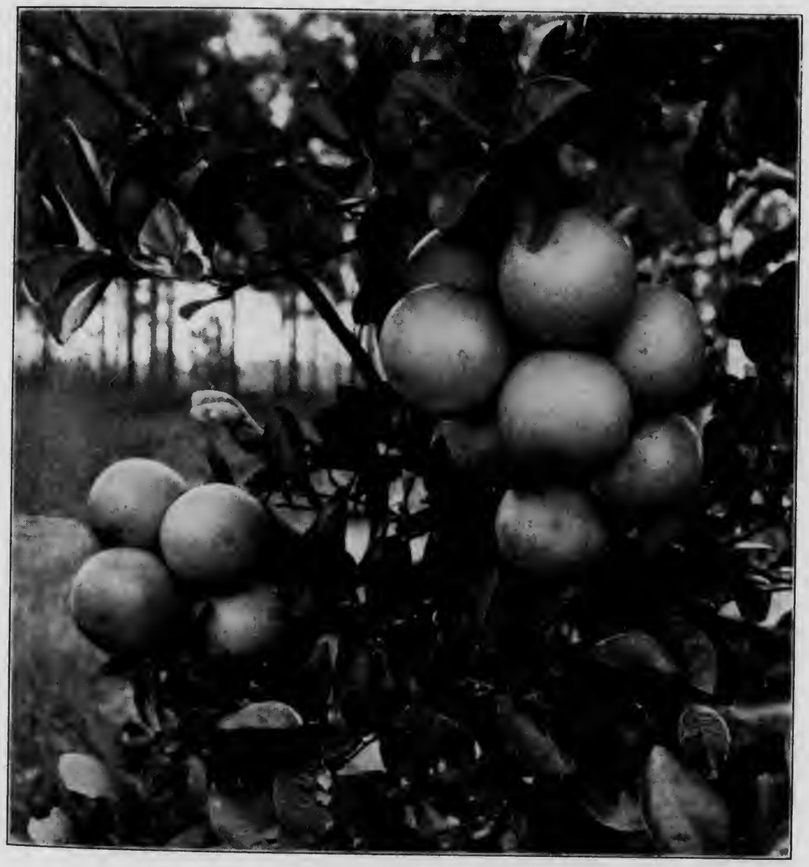

FIG. 15

from seeds and therefore have no name. These seedling trees produce good fruit and meet a ready sale on the market. Practically all that the grower cares to know about grapefruit is that its quality is good as judged by the market and that it can be disposed of.

36. Some of the most popular budded varieties of grapefruit for home and commercial groves are described in the following paragraphs. Of these, the Duncan, Marsh's Seedless, and the Walters are the most largely planted in commercial groves in Florida. In the other gulf-coast sections the Duncan is the most popular commercial variety.

37. The **Triumph** is one of the earliest varieties of grapefruit to ripen in the season. The fruit is slightly flattened in form; the skin is smooth and light yellow in color. The fruit is heavy, juicy, and the flesh is well flavored in that the sweetness and acidity are about normal. The flesh is less bitter than that of some other varieties. The pulp is somewhat woody. The tree grows vigorously and is prolific, but fairly tender, and hence is not recommended for the northern districts. On account of the size of the fruit, which is small, it is not desirable for commercial use. For this reason in recent years many plantings of the Triumph variety have been budded over to more desirable commercial varieties. It is useful for early fruit for home use and sells fairly well in the markets. A branch of Triumph grapefruit is shown in Fig. 15. The flattened form and smooth skin can be plainly seen.

38. The **Hall,** or *Hall's Silver Cluster*, is a variety of grapefruit that ripens in midseason and has many good qualities that adapt it to Florida conditions. The fruit is nearly round in form, although sometimes flattened; it is large in size, and light yellow in color, but often the color is a darker yellow than is found in most varieties of grapefruit. The quality is good. The tree bears heavily, and the fruit is borne largely in clusters, as is indicated by the name. The season is February and March, but the fruit hangs well on the tree and can often be marketed later than March.

39. The **Walters** is a midseason variety that is well thought of by many Florida citrus growers. The fruit is somewhat flattened in form, from medium to large in size, and pale yellow in color. The quality is very good, and the bitter characteristic is strongly marked. The trees grow vigorously

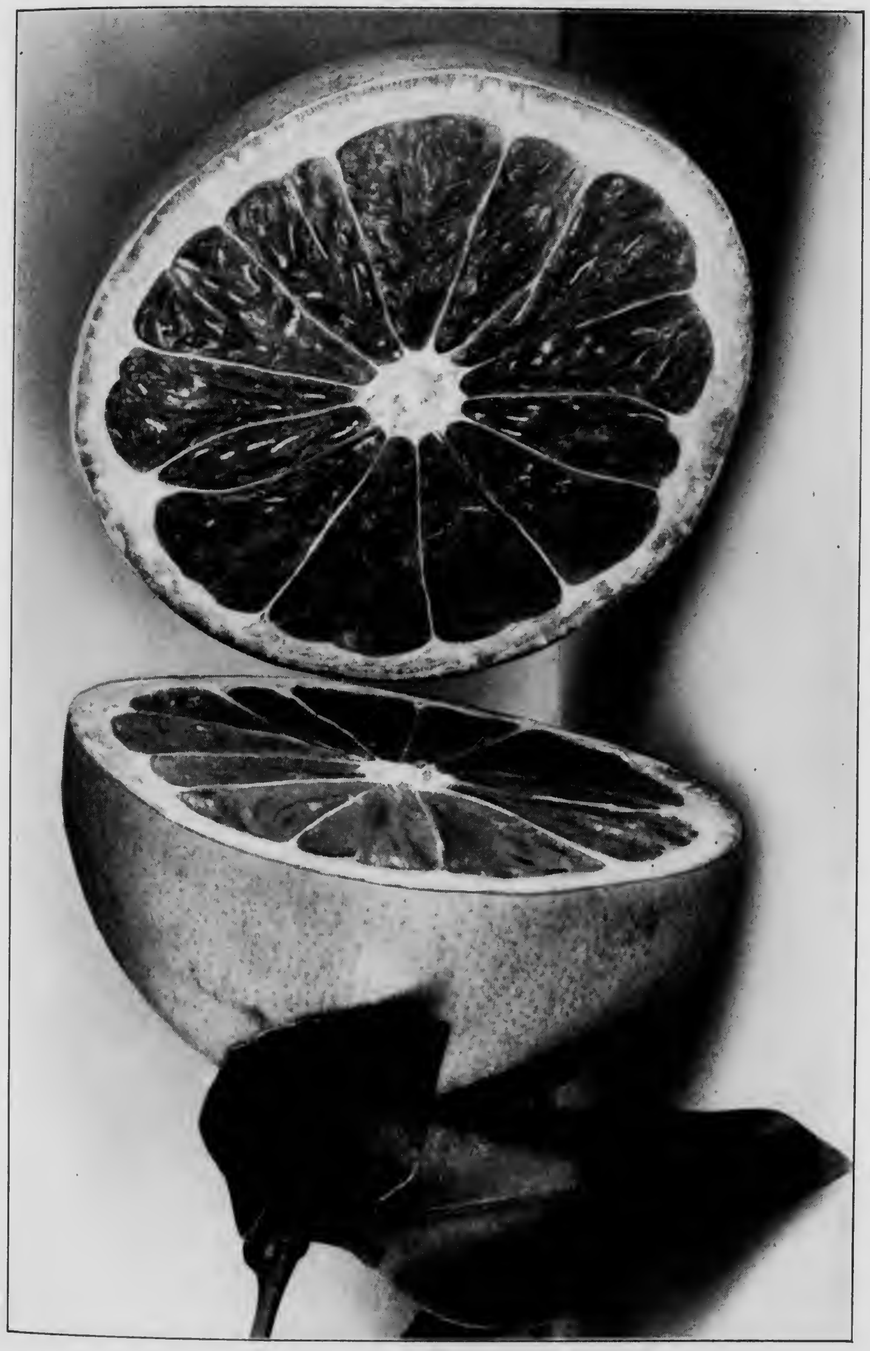

FIG. 16

and are prolific and often the fruit is borne in clusters similar to the Hall. The season is February and March, but the fruit hangs so well to the tree that often it can be marketed later in the season.

40. The **Marsh,** or *Marsh's Seedless*, grapefruit is a desirable variety for general planting in Florida, largely on account of its nearly seedless character. The fruit is slightly flattened in form; it is large in size and light yellow in color. The rind is thin and smooth. The quality is fairly good, but the fruit lacks somewhat the pronounced flavor of most grapefruit, and the bitter characteristic is not strongly developed. The fruit is generally seedless, although occasionally from two to six seeds are present. The practically seedless character of this variety is shown in Fig. 16. The season is February and March.

41. The **Pernambuco** variety was imported by the United States Department of Agriculture from Brazil some years ago. The form is slightly flattened, the size is large, and the color is a lighter yellow than that of most varieties of grapefruit. The skin is smooth and fairly thick. The acidity and sweetness is good and the bitterness is pronounced. The season is late, about March and April, but the fruit hangs well to the trees and may often be marketed in May and the first part of June.

42. The **Duncan** variety of grapefruit matures late in the season. It is flattened in form, large in size, and light yellow in color. The peel is tough and smooth, and the quality is of the best. The flavor is excellent, the acidity and sweetness being well blended, and the desired grapefruit bitterness is present. The trees are prolific, grow vigorously, and bear regularly. The fruit will hang to the tree until May or the first of June. In Fig. 17 is shown a branch of Duncan grapefruit. Note the flattened form and the smoothness of the peel. In Fig. 18 is shown a fruit severed to show the character of the pulp and the seeds. In respect to seeds, this variety is similar to most other varieties.

FIG. 17

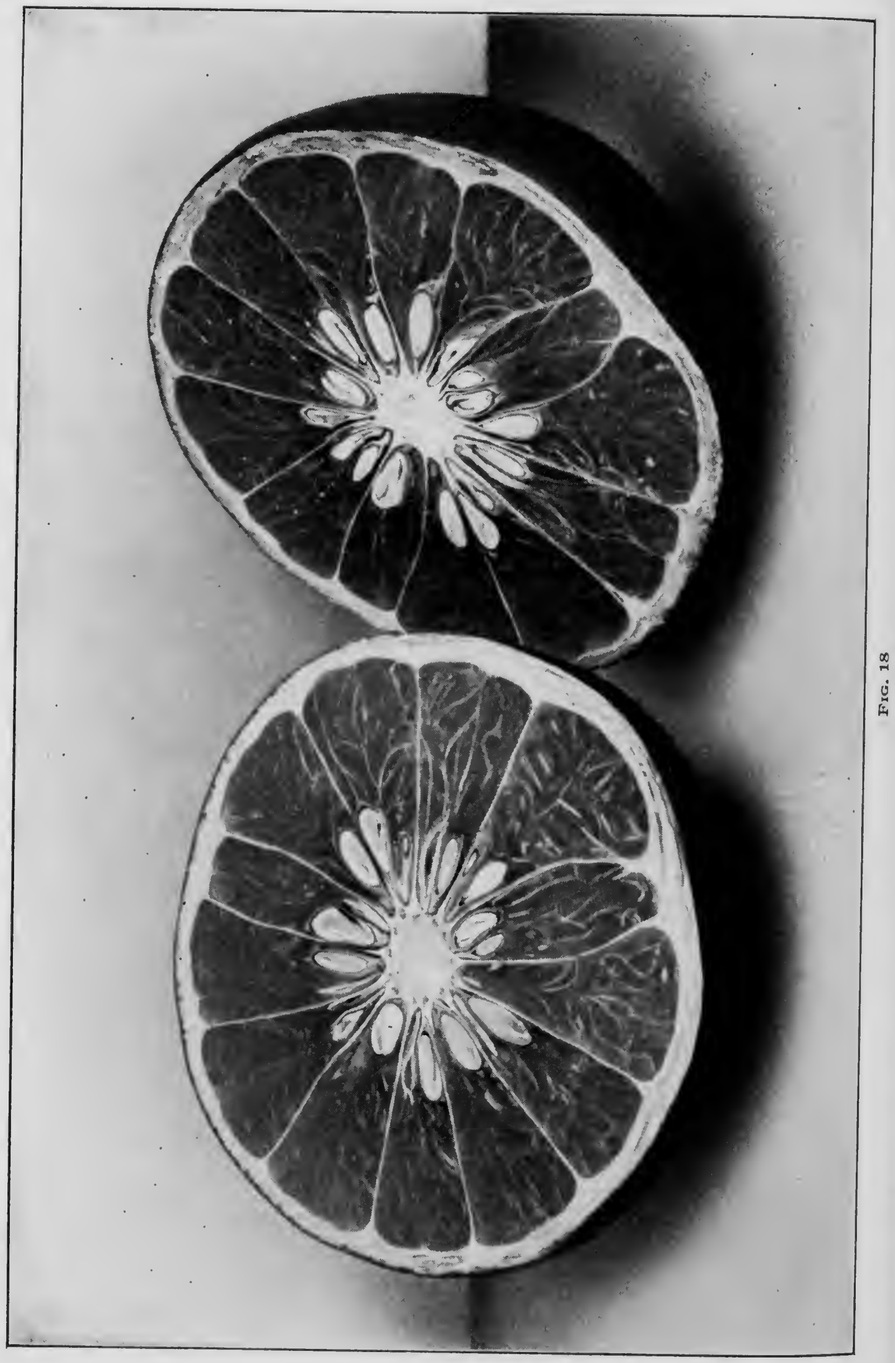

FIG. 18

The Duncan is the best of all the varieties so far introduced for general commercial plantings. It is especially adapted to the colder sections on account of its hardiness. For this reason, in the coast districts of West Florida and in Alabama, Mississippi, Louisiana, and Texas it should have preference as a commercial variety.

VARIETIES OF LEMONS AND LIMES

43. Although lemons and limes are not grown to any extent commercially in Florida, nurserymen have a few varieties for those who wish to raise the fruit for home use or for local sale. The varieties that are most largely planted are described in the following paragraphs.

44. Varieties of Lemons.—The **Villafranca** is the variety of lemon most largely planted in Florida and in the other gulf citrus regions. The lemon of this variety is oblong-oval in form, medium to large in size, and bright lemon yellow in color. The juice is abundant and the acidity is strongly marked. The trees grow vigorously, are productive, and have but few thorns.

A so-called seedless variety of Villafranca that is offered for sale by some nurserymen originated near Dunedin, Florida; it closely resembles the true Villafranca, but it is somewhat smaller and practically seedless, although in occasional specimens a few seeds are found.

45. The **Ponderosa** is a variety of lemon that is valuable as a home fruit. The form is oblong, flattened at the base, and somewhat pointed at the stem end, and the size is exceptionally large, the fruits often weighing as much as 2 pounds. The lemon is juicy, of good flavor, and excellent in quality. The trees are about as hardy as those of other varieties of lemons.

46. Varieties of Limes.—The Mexican lime, known also as the Key lime, as stated previously, grows without cultivation on the islands near the Florida coast. Seedling trees of this variety are sold by nurserymen under the name Mexican.

Due to propagation from seeds, the size and quality of the fruit as well as the nature of the tree is very variable. Some trees obtained from the nursery may be prolific and produce good fruit, and others may not have these desirable characteristics. The name Mexican is not applied to any one variety, but rather to many varieties that have been derived from the sowing of seed obtained from various sources.

The fruit of the Mexican lime, however, which is supposed to be typical, is oblong or oval in form and small in size, averaging about 1½ to 2 inches in length, although under cultivation the fruit sometimes attains a larger size; the lime, when ripe, is light lemon yellow in color. The flesh is fine grained and light green in color. The flavor is distinctly that of the lime. The fruit matures throughout the entire year, generally about four crops being produced in a year.

47. The **Tahiti** is a budded variety of lime that produces fruit about the size of the average lemon. The fruit is oblong in form, lemon yellow in color, and the flavor is distinctly lime; the juice is plentiful; and the pulp is greenish in color. The rind is smooth and thin. The trees grow vigorously and are fairly hardy and prolific. The variety is well adapted for home use, and the fruit can often be sold locally at a good price.

SELECTION OF LOCALITY AND SITE

SELECTION OF LOCALITY

48. In the selection of a location for citrus culture, many factors should be considered. The susceptibility of the section to frost and freezes, market and transportation facilities, nature of the soil, the price of land, and the prevalence of winds are some of the most important factors.

It is difficult to say just what sections or counties in Florida and the other gulf-coast states have the conditions best adapted for citrus culture. The most practical way for a prospective grower to find out the good and bad features of the section in

which he desires to locate is to go there and make a thorough study of the conditions that have an influence on citrus culture. It is often difficult to know just where to get the necessary information. The state experiment station is usually in touch with conditions and growers over the state, and for this reason it is best for the prospective purchaser to go to the station and learn as far as possible from the men there the advantages and disadvantages of each citrus section in the state. Letters of introduction to prominent growers can usually be obtained from the men in charge.

49. Prevalence of Frost.—The temperature conditions should be ascertained as accurately as possible. These can be learned by talking with growers who are familiar with the section and by examining thermometer records for previous years. A few growers and managers of large citrus groves have such records, and if the prospective purchaser is tactful he is likely to be allowed to examine them. Growers are sometimes reluctant to show such records or to give accurate information about the temperature conditions of a locality, but usually it is possible to secure the desired information.

As stated in a previous section, bodies of water have much to do with equalizing the temperature of adjacent land; consequently, it is very desirable to locate near a lake or a river. In most sections of Florida, the south or the east side of a lake or river is preferable to the west or the north side, for the reason that in nearly all parts of the state cold winds that may bring a freeze come from the north or the west. Such winds passing over water, even if it is a small lake or a comparatively narrow river, will be tempered by the water. Records show that at times there is a difference of from 6° to 10° F. in temperature between the north and the south side of a river or lake. In the Pinellas Peninsula the coldest winds come from the northeast. The winds from the northwest pass over the Gulf of Mexico and are tempered before reaching the land. In other sections certain local conditions may exert an influence. In the other gulf-coast states nearness to the Gulf of Mexico is usually desirable on account of climatic conditions.

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Cold air drains down hill and warmer air takes its place. Low-lying ground is often subject to frost, whereas higher ground is likely to be less subject to it, and therefore there is less danger of damage. Even in Florida, where the land is so nearly level, a slight elevation has a noticeable influence. In Florida, land that has a slope to a lake or a river or to lower-lying land is usually more free from frost than low areas and this is often an important condition to note when selecting a location for a grove.

50. Markets and Transportation.—Since citrus fruits thrive only in regions where there is no severe winter, the grower must, of necessity, be located at some distance from his best markets. A grower need not concern himself about his market in locating a grove, but the transportation and packing-house facilities should be considered. A location near a shipping station and a packing house is desirable. Overland hauls of 10 or 12 miles to the shipping point or packing house are expensive and add to the cost of marketing the fruit, and if the roads are bad the fruit is apt to be bruised and may reach the market in poor condition. Also, there is additional expense for hauling fertilizer and other materials to the grove, and the hauling must usually be done at a season when the labor is needed in the grove. A veteran orange grower of Florida was recently heard to say that he would not accept as a gift land five miles from a shipping station or a packing house for the purpose of setting out a grove. The distance it pays to haul fruit varies with the condition of the roads and the method employed. If the roads are smooth, the surface hard, and auto trucks are used, the distance obviously could be greater than if the roads were bad and horses or mules used. A distance of 10 miles under the former conditions would be better than 4 or 5 miles under the latter.

It is desirable if the grower can locate near two railroads, for usually better shipping service can be obtained. Transportation by water is usually cheaper than by rail, but it has the disadvantages of being somewhat slower. In all transportation facilities it is well to consider whether it goes on a

direct line to important market centers. Branch lines are sometimes slow in handling shipments.

51. Soils.—In Florida, the different kinds of soil are designated largely by the kind of trees that grow on the land, and, also, by the topography. High pine land, flat woods land, low hammock land, and high hammock land are the soils on which citrus fruits are grown successfully in Florida.

High pine land has a good elevation and is usually well drained. In its virgin state it supports a growth of long-leaf pine. In some places a few deciduous trees, mostly willow oaks, are found growing with the pine trees. Land of this kind is in most instances easy to clear. As a rule, the soil is a sand or a light sandy loam, with a fair amount of humus and in places is underlaid with a clay subsoil. The soil of the high pine lands is not rich, but, being sandy, it responds very readily to fertilization and makes very good citrus soil.

The flat woods land is of lower elevation than the high pine land and the ground is flat and level. In the northern part of the state it supports a growth of long-leaf pine, and in the southern part a growth of Cuban pine. There is often an undergrowth of saw palmetto and gallberry. In case of clearing it ranks with the high pine land. The soil is sandy, contains a large amount of humus, and may be underlaid with clay, hard pan, or rock. Much of the flat woods land is of fair elevation and is well drained, and such land, like the high pine land, is well adapted for citrus fruits. The low, flat woods land that is not easily drained is not adapted for citrus growing.

Hammock lands in a virgin state produce a growth of hardwood, evergreen, and deciduous trees. Among the varieties of trees found on hammock land are holly, hickory, live oak, dogwood, magnolia, and cabbage palmetto. The high hammock lands are of comparatively high elevation and are well drained. They are often rather expensive to clear but are well supplied with humus. They are rich and deep, and make excellent citrus soils.

The low hammock soils are similar to the high hammock soils, except in the matter of elevation and that they support

a larger growth of cabbage palmetto and live oak. They are often difficult and expensive to clear, but are rich in fertility and contain abundant humus; they usually make good citrus soils unless they are so low that they are poorly drained.

52. The importance of soil drainage cannot be too strongly emphasized for citrus groves in Florida. Since much of the land in the state is in need of drainage, it is to be expected that many groves are located on soil that is unsuitable on account of lack of drainage. The water-table should be at least 1½ feet below the surface of the ground, and it is better if it is much deeper, say from 6 to 10 feet. Water standing at or very near the surface of the ground for some time will kill or injure the trees. Florida is subject to periods of excessive rainfall, and during such periods the soil should be well drained so that the water will be removed immediately. Drainage ditches are necessary nearly everywhere in the citrus regions, and they should be large enough to carry off excessive rainfall. Natural drainage is, or course, important, and should receive consideration when a location for a grove is selected.

Although Florida has a heavy rainfall and much of the land is low and in need of artificial drainage, yet there are times when moisture is deficient in the soil. At such times irrigation would prove an advantage. It is sometimes desirable to be near a water supply convenient for irrigating the grove.

53. In Alabama, sandy hammocks are preferred for citrus groves. On these hammocks the timber growth consists or consisted largely of magnolia, hickory, and oak. The soil is underlaid with clay. For best results, the clay should be within 12 to 18 inches of the surface, for if it is too far below the surface the blooms are likely to drop and as a result there can be no fruit. As in Florida, good drainage is necessary. The underlying subsoil should be sufficiently porous to allow moisture to pass through it or ditches should be made to carry off excess water.

54. In Mississippi, planters prefer the so-called Norfolk loam type of soil for citrus trees. This is a sandy loam that is underlaid with a clay subsoil, and usually is well drained.

Concerning soils for citrus trees in Louisiana, a prominent planter of Plaquemines Parish states that he considers the best citrus soils in his locality to be those containing plenty of humus, but not too heavy, and that they must be well drained. The citrus soils in Louisiana are of alluvial formation and are somewhat richer than the soils in the other citrus regions of the gulf coast; this condition is taken advantage of when fertilizing the groves after the trees are planted.

55. In Texas the lighter soils of the coastal plain have been found more satisfactory than heavier soils. As in other localities, they should be well drained, and not be too rich. Experience in Texas shows that trees on the lighter, poorer soils go through the winter in better condition than those in heavier, richer soils, due to the fact that the wood of trees on rich soils is seldom hardened enough to pass through the winter without danger.

56. In connection with soil for citrus trees, no matter which state is being considered, it should be stated that citrus trees can be grown on almost any type of soil, from sticky adobe to almost sterile sandy soils. Rich soils will produce citrus trees of rank growth that often will bear large crops of fruit, but usually the quality of the fruit is not of the best. Sandy soils that are almost sterile will, on the contrary, produce fine crops of fruit if the proper kinds and amounts of fertilizer are applied.

57. Price of Land.—The price of land, the cost of clearing it, the expense necessary to get a grove into bearing, the prices that have been received for bearing groves, the profits that have been made on bearing groves, and the amount of money spent annually on groves should all be discussed with growers and the statements for the different sections compared. Naturally there will be much variation in the reports given by individuals, but with all of the data collected a man should be able to form some opinion of the expense necessary to maintain groves in the different citrus sections.

SELECTION OF SITE

58. Many times the location chosen for a citrus grove is of such a nature that it will not permit of much choice for a site. The land may be perfectly flat, or the soil may be uniform in drainage conditions throughout, or prevailing winds may be of such a nature that no natural protection can be secured on any part of the location. On the other hand, many locations vary in their topographic features, some areas being higher than others, and the soil of these areas is better drained than that of others; or a part of the location is less subject to prevailing winds than another part, and one part may even be protected from the effects of prevailing winds by a natural wood growth that acts as a windbreak. When the locations vary in this way, topography of the land, protection from prevailing winds, and soil conditions should be carefully considered.

The ideal site for a citrus grove is one which is elevated somewhat above adjoining lands. Such a site, even if it is only slightly elevated, frequently serves as a protection against frost. Such elevated areas also usually have better water drainage, which is most important for citrus trees.

59. Excessive winds injure both the foliage and the fruit of the trees by whipping the branches. This removes many leaves and much fruit, and, in addition, fruit that remains on the trees may be so bruised that it will become an easy prey to disease, or its appearance will be spoiled and hence it will bring a less price on the market. High winds carry off moisture from the soil and often bring dry, parching air that is very injurious to the trees.

A natural forest makes a very effective windbreak, and one that protects a grove from the prevailing winds is often a large asset. In case no natural protection is afforded, a windbreak of trees may be planted, or an artificial one of some kind constructed, but either of these methods means an outlay of both time and money.

60. Usually the soil will be uniform throughout the entire location, but still there may be slight local differences. High

hammock land may grade into low hammock, or high pine land into flat woods land. In certain spots the soil may be so shallow that it will not support a citrus tree, or it may be such coarse sand that no matter how much humus-making material and fertilizer are applied, it cannot retain any quantity of humus and plant-food. Factors concerning the soil for citrus groves will be brought out in subsequent pages of the text, and all such should be given due consideration when selecting a site.

PROPAGATION OF CITRUS TREES

61. Citrus trees can be propagated by seeds, by layers, by cuttings, by grafts, and by buds. Formerly most of the groves were planted with trees grown from seeds. Such trees are known as seedlings. There are still many citrus groves that consist largely of seedling trees; in fact, many of these old seedling trees are the parents of the desirable varieties of citrus fruits that are most largely planted today. However, citrus trees grown from seeds have several great disadvantages in that they do not reproduce the exact characteristics of the parent. Sometimes the tree from the seed may be the most prolific and produce the most desirable fruit, but frequently the opposite is the case. Often citrus trees grown from seeds produce fruit of good quality, but the fruit from many seedlings is usually small and not uniform in size. It cannot be predicted with any degree of certainty what kind of fruit a tree grown from a seed will produce. In addition, the trees usually make a vigorous growth and are long in coming into bearing.

The seedling tree, however, should not be lost sight of entirely, for, as was stated previously, trees grown from seed have been the source of all the citrus varieties grown today, and just as new varieties have been produced in the past so it may be possible to produce new varieties in the future. Seedling trees should be planted for experimental rather than for commercial purposes. The grower who aims to produce high-quality fruit should plant trees of varieties of known value. Better and quicker results in the origination of new varieties will follow,

however, if citrus trees of known value are artificially crossed with each other. The seeds from the fruits produced after the cross can be sown and oftentimes the results are better than if seed from a fruit, the flower of which was fertilized by pollen from an unknown tree, is sown.

62. Propagation by layers, by cuttings, or by grafts is seldom practiced for citrus trees planted in commercial groves, and although there may be occasions when these methods might be used, they are not of sufficient importance to be discussed here.

The most common method employed in propagating citrus trees is by budding. The nursery stock is grown from seeds and when the trees have reached sufficient size they are budded to a known variety. Mature trees can also be budded. A bud is inserted into the bark of a branch, and when this bud has grown sufficiently the old branch is removed.

The grower has several advantages in planting trees that have been propagated by buds: (1) A crop of fruit uniform in quality can be secured. (2) Varieties ripening at different seasons can be planted and a succession of fruits can be had from early to late in the season. (3) Varieties of citrus trees can be used as stocks that will grow under a wider range of soil and climatic conditions and thus varieties of citrus can be grown in soils where it would not be possible to grow them if they were on their own roots. (4) Diseases such as maldigoma, or foot rot, which at one time was the dreaded disease of the sweet orange and the lemon, can largely be avoided by using trees as stocks that are resistant to it.

63. Stocks for Citrus Trees.—Any variety of citrus can be budded to any other variety, and, provided all conditions of growth are favorable, the bud will grow and produce a tree or a branch of the same variety as itself. Experience proves that some varieties of citrus are more desirable under some conditions as stocks for budding than are other varieties; and, further, that each citrus-producing section has a stock or stocks best suited to local conditions. In Florida the stocks

used are known as sour, or wild, orange, rough lemon, grapefruit, and Citrus trifoliata. In the other gulf-coast states, the Citrus trifoliata is the principal stock used. Not all of these stocks are adapted to the same conditions of soil and climate and neither can it be said that any one of them is best for all conditions. The grower should familiarize himself with the relative adaptability of these stocks to different soil and climatic conditions, and at the same time be thoroughly familiar with the soil and climatic conditions in the region in which the stocks are to be planted. Citrus trees on sweet-orange stock should never be planted on a heavy, damp soil, but should be planted on light or sandy soil. It also would not be advisable to plant citrus trees on trifoliata stock on dry, loose, open ridges, since it thrives on a heavier soil.

64. The sour-orange tree, next to the trifoliata, is the hardiest of all the varieties or species of citrus trees. When subject to frosts, the sour-orange tree will show no effect whatever at times, whereas other orange trees will be severely injured.

The sour-orange tree produces abundant root growth which penetrates well into the soil and enables it to draw a supply of water from a larger area. It is strongly resistant to the attacks of maldigoma, or foot rot, to which the sweet orange is subject. The sour stock sprouts readily from the roots if the top is frozen back and thus gives an opportunity for rebudding.

Sour-orange trees thrive best naturally in soils containing a liberal supply of humus and moisture and are found growing wild on the shores of lakes and banks of rivers where there is a liberal supply of humus and moisture. It is recommended as stock for citrus trees that are to be planted on high and low hammock lands; on light soils it is a failure because of the extreme slowness of growth.

65. The rough lemon tree, like the sour-orange tree, grows wild in the southern part of Florida. It does not grow in Northern Florida, because at some seasons of the year the climate is too cold. The roots of this tree are usually well distributed through the soil. Rough lemon stock is capable of inducing a

more rapid growth in the bud worked on it than any other lemon stock used in this country. For this reason and on account of the roots having great foraging powers for plant-food, it is recommended for those who want to grow a grove in a hurry, especially on high, dry soils not plentifully supplied with plant-food. It should never be planted on low, wet, or badly drained lands. The rough lemon tree is as resistant to foot rot as is the sour-orange tree. Fruit from trees on rough lemon stock are oftentimes inferior in quality to fruit of the same variety on other stocks. Fruit from trees grown on this stock cannot be held so late as fruit of the same variety that has been grown on sour-orange stock, neither does the fruit have such lasting qualities.

66. The pomelo, or grapefruit, tree is used as stock to a limited extent in Florida. Some growers in the extreme southern parts of the state prefer it to any other. It seems adapted, also, to lands in Central and South Florida that contain a considerable quantity of humus. It is not as hardy as the sour orange, is a fairly rapid grower, although not as rapid as the rough lemon, and makes a strong root growth. Its lasting quality is said to be better than that of the rough lemon, but it is hardly equal to that of the sour orange.

67. The Citrus trifoliata is very resistant to cold temperature. It thrives best in the cooler citrus sections and has been known to withstand a temperature below zero. It is claimed by some authorities that the stock has, in some degree, the power, in colder regions, of imparting to varieties worked on it some of its own hardiness. It has a tendency to retard growth in the spring and is not responsive to sudden changes of temperature during the dormant period. In the cooler regions of Northern Florida, and in Alabama, Mississippi, Louisiana, and Texas south to Beeville on soils that are well supplied with moisture and are capable of retaining it, such as a heavy soil, this variety of citrus does well as a stock. The trifoliata orange should never be used as a stock on high, dry, or calcareous soils. For Southern and Central Florida, it is not recommended.

68. Securing of Seed for the Growing of Stocks. The seeds from which stocks are to be grown should be plump and well filled out and should be taken from vigorous trees. The following data on seed was compiled by H. H. Hume, President of the Florida State Horticultural Society, and will be found useful:

Sour-orange seed: Weight per bushel, 32 pounds; number of seeds per quart, 2,100; yield of seed from seventy fruits, 1 quart.

Grapefruit seed: Weight per bushel, 32 pounds; number of seeds per quart, 1,400; yield of seed from forty fruits, 1 quart.

Rough lemon seed: Weight per bushel, 32 pounds; number of seeds per quart, 6,700; the number of seeds in the fruit varies, but the average is twenty-two each.

Citrus trifoliata seed: Weight per bushel, 50 pounds; number of seeds per quart, 2,600; yield of seed from one hundred and thirty-eight fruits, 1 quart.

The figures for the number of seeds in a quart and for the number of fruits that will yield 1 quart of seed may vary at times, but they will prove to be fairly accurate for a number of tests.

69. The common method of removing the seeds from citrus fruits is to allow the fruit to rot, then to pulp it in a barrel and remove the free pulp and juice by floating it off with running water. The contents of the barrel are then poured on a sieve coarse enough to hold the seeds. The seeds are then thoroughly washed to remove any adhering pulp. If the seeds are to be planted as soon as they are dry on the outside, it is important that no pulp adheres to them. Pulp may cause the soil around the seed to become sour and cause the resulting seedling to rot or decay. Organic matter nearly always contains the organisms of decay. It is also a good plan to remove any seeds that do not sink; the small, imperfect ones are likely to float on the surface of the water and the plump, desirable seeds to sink.

Another method frequently employed for removing the seeds is to cut the fruits in half and gouge the seeds out of the halves by means of a piece of round wood about $2\frac{1}{2}$ inches in diameter, rounded at the end and grooved like the ordinary lemon squeezer. The half fruit is held in one hand, the rounded end

of the stick inserted in it, and with a twist of the wrist the entire contents of juice, pulp, and seed are taken out and allowed to drop into a bucket or tub. The juice and pulp can then be removed by floating it off with running water and the seeds washed as already described.

After the seeds are washed they should be spread out thinly in the sun and left just long enough to dry off on the outside. To hasten drying they should be turned over from time to time. Under good weather conditions a day or two is sufficient time in which to dry the seeds. In cloudy or damp weather the drying may require a longer time.

After the seeds are dried off on the outside, they may be planted at once or stored. If they are stored, care must be taken not to allow them to dry on the inside, for if they dry out to the extent that the inner parts separate, the life will be destroyed. The best plan for preparing seeds for storage or shipment is to mix them with an equal bulk of finely pulverized charcoal and store them in tight boxes or cans. They can be kept in this way for several months.

70. Planting of Seeds.—When only a few thousand seedlings are to be grown, the seeds are sown either in flats or in cold frames; when a larger number is to be grown, the seeds are sown in a seed-bed in the open. The flats are about 2 feet square, 6 or 8 inches deep, and have holes cut in the bottom to provide drainage. The soil should be a sandy loam and should come within 2 or 3 inches of the top of the flat. The soil is smoothed off, the seeds placed rather close together in rows 3 inches apart, and over them is sprinkled about $\frac{1}{2}$ inch of sand or loam. To prevent the soil from drying out too quickly, an inch or so of decayed leaves or other mulching material may be placed over the sand or loam. The flat is then placed in a warm place, usually away from the direct rays of the sun, and the seeds allowed to germinate. After the young plants begin to come up the layer of mulching material should be removed and the plants should be thinned to stand $2\frac{1}{2}$ to 3 inches apart. The young plants are allowed to grow until they are from 6 to 8 inches high.

When seedlings are grown in cold frames, the seeds are usually planted in the soil of the frame in rows about 6 to 8 inches apart and the seeds an inch or so apart in the rows. The seedlings grow in the frame until they are 6 or 8 inches high, when they are ready to be transplanted to the nursery row.

Nurserymen and growers who raise a large number of seedlings plant the seeds in seed-beds in the open. Great care should be taken in selecting the place for a seed-bed. The soil should be an easily worked loam, fairly moist, but the location should not be one that is likely to be flooded at times. Many growers arrange for irrigating the seed-bed and are thus practically able to control moisture conditions in the soil.

The soil of the seed-bed should be thoroughly prepared, about 3 or 4 weeks before the seeds are planted, by working it carefully with tillage implements. If the soil is deficient in fertility, plant-food should be applied at this time. The fertilizer should be broadcasted over the surface of the seed-bed and cultivated into the soil. It is unsafe to apply commercial fertilizer and then plant seeds immediately afterwards. The fertilizer should have sufficient time to be thoroughly incorporated into the soil. What is termed grower fertilizer is used for a seed-bed. Such fertilizer is rather rich in nitrogen, and tends to produce luxuriant, growthy plants. Details concerning the amount and kinds of plant-food in such fertilizers are given in a subsequent Section.

When ready to plant the seeds, the ground is smoothed and the rows about 2 feet apart are indicated on the seed-bed by stakes. Furrows about 6 inches wide and 5 inches deep are plowed out for the rows. In these furrows the seeds are scattered about an inch apart and about an inch of soil is placed over them and firmed down. The young plants grow here until they are ready to be transplanted to the nursery row, the ground during their growth being kept free from weeds and watered when necessary.

71. Time for Sowing Seeds.—The seeds of Citrus trifoliata may be planted as soon as the fruit is ripe, in September or October. Unlike the sour orange, rough lemon, or grape-

fruit seedling, the little seedlings of Citrus trifoliata are not injured by being frosted. Even though the tops may be injured, the top is quickly renewed from buds on the tiny stem beneath the surface of the soil. If, on the other hand, the top buds of the tiny seedlings of the sour orange, rough lemon, or grapefruit have been injured by frost, winds, or sun they do not sprout out again and the plants die. For this reason, seeds of these latter kinds of citrus should not be planted until all danger of frost is past. This will be in December in Southern Florida, and in February or March in Northern Florida. The exact date will depend largely on the location and the season.

72. Care of Seed-Bed.—The citrus seed-bed should be thoroughly cultivated. It is important that moisture be conserved, that weeds be kept from growing, and that any hard crust that tends to form on the surface of the soil be broken. For cultivating and breaking the crust in the rows where the seeds are sown, a prong hoe is useful. A careful workman may hoe around the young seedlings when they are coming through the ground with entire safety to the young plants. The ground between the rows can be cultivated with a one-horse cultivator. Cultivation should be repeated every 8 or 10 days throughout the season. In the sandy soils of Florida the cultivation need never be deeper than 2 or 3 inches, for deeper cultivation does not add to the productiveness of the soil, but may injure the roots of the seedlings.

73. Transplanting the Seedlings.—The length of time the seedlings remain in the seed-bed varies with climatic conditions and the growth of the plants. By autumn or winter following the planting, the seedlings should be from 6 to 12 inches high and about $\frac{1}{4}$ inch or more in diameter. As far as size is concerned they are ready to transplant, and in Southern Florida transplanting can be done successfully as soon as the trees have reached this size. In Central and Northern Florida, transplanting is generally delayed, however, until the spring or the early summer, when the ground is warm and moist. Seedlings are sometimes left in the ground until they have had two seasons' growth; the extra growth will do no harm. Either

a spade or a tree digger can be used for removing the seedlings. The tree digger is an instrument that loosens the ground on both sides of the tree row and at the same time cuts off most of the tap root. These implements are generally employed by nurserymen who grow large numbers of trees. If the digging is done with a spade, it should be shoved down beside the tree to a depth of 8 to 10 inches, the ground loosened, and the tap root severed by the spade. The seedling can then be lifted out easily. The tap root will need to be trimmed back slightly to insure a well-branched root system, and the side roots cut off to make planting easier. The trees should be covered immediately with a wet blanket or a piece of wet burlap to prevent the roots from drying out.

74. Ground for the Nursery.—The ground to be used for a nursery should be carefully selected. Soil that is light and mellow at the surface and underlaid with a rather heavy clay not too near the surface is preferable for a citrus nursery. It should be fairly moist yet well drained. If the soil is of such a nature that it is subject to droughts at certain seasons of the year, it is a good plan to provide some means for irrigating it. The growing and turning under of a leguminous cover crop on the ground the year previous to transplanting is excellent practice, because it opens the soil and provides humus and nitrogen for the young trees. The soil in the nursery should be brought into good tilth by cultivation before the seedlings are transplanted into it. In Florida, most of the light soils are deficient in plant-food. For this reason, light nursery soils should receive from 500 to 1,000, pounds of commercial fertilizer per acre, the amount depending on the richness of the soil. The fertilizer should be given in two or three applications rather than at one time and should be thoroughly cultivated into the soil. The first application of fertilizer should be made before the seedlings are set in the nursery; the other applications should be made during the growing season at intervals of 1 or 2 months.

75. Preparatory to setting the trees, the ground should be leveled and the rows marked off from $3\frac{1}{2}$ to 4 feet apart, in order

that horse cultivation of the trees will be possible. The trees are placed from 12 to 15 inches apart in the rows. The trees are set at about the same depth they stood in the nursery and the soil is well firmed about the roots. Some nurserymen use a spade to open the soil where the tree will stand, and after inserting the tree press the soil firmly about the roots with the feet. Others plow out a furrow and after placing the trees in the furrow and pressing the soil about the roots with the feet, fill the furrow again by plowing the soil back into it. Following the setting of the young trees the soil should be watered, if necessary, and all during the growth of the trees the moisture content of the soil should be such that the young trees never suffer from a lack of water. Cultivation of the nursery should be frequent and thorough throughout the entire growing season. A one-horse cultivator should be run between the rows every 8 or 10 days, depending on the condition of the soil. Cultivation should not be continued late in the fall, however, for late cultivation, on account of the stimulating effect on the trees, means that they will enter the winter with a vigorous, succulent growth and therefore are likely to be injured even by a slight frost. If cultivation is stopped early, say about August or September, the exact time depending on the weather conditions, the wood of the trees will harden up sufficiently.

76. Budding the Seedlings.—The young trees are ready for budding when they are about $\frac{1}{2}$ inch in diameter at the crown. Usually this means that they will be about 2 years old, although occasionally stocks grown from seed planted early in the spring may be large enough to bud in the fall. There is no age limit beyond which the tree can be budded, and often they are allowed to grow in the nursery for a longer period before being budded. Citrus trees are not periodic in growth as are deciduous trees, but when properly fertilized and watered will make three or more growths during the spring and summer, and after each growth the wood hardens before the next begins. This hardening state is a period of rest, and during this time the bark does not slip as well as during a growing period. In regions where a more or less definite winter season occurs,

there will be a dormant period of two or three months. During this season it is difficult to insert the buds, since the bark does not slip readily. Buds may be inserted to the best advantage in the stock at any season when the bark slips well. Thus, they can be inserted during the growth period in spring, in summer, or in the fall.

77. Budding in the fall is known as *dormant budding*. Dormant buds in the colder sections are often protected during the winter by throwing a furrow of soil against them. Even if the tree above the bud is frozen back no harm will result unless the bud itself is injured. If budding is done early in the spring it is called *spring budding;* and if it is done just before the beginning of the rainy season, about June, it is known as *summer budding*.

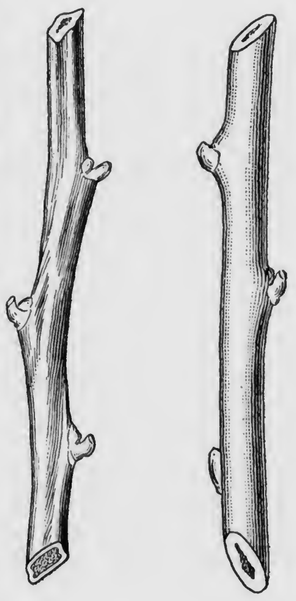

FIG. 19

78. The method of budding citrus trees is similar to the method of budding deciduous trees described in a previous Section, but in order that the differences may be known the method of budding a citrus tree is given here in detail. The stick from which the buds are taken should be fairly well matured wood of the current season's growth. The young growth is at first somewhat angular like that shown in Fig. 19 (*a*), but as the twig matures it becomes more round, as shown in (*b*). For ordinary shield budding, buds from round wood without thorns are preferable, but in case it is difficult to get buds from well-rounded wood, they may be taken from angular wood. As far as possible, bud wood that is free from thorns should be chosen. Thorns are undesirable on citrus trees, and every effort should be made to eliminate them. Buds from diseased and unthrifty trees should also be avoided; the parent should be healthy, vigorous, and productive.

275—21

79. In sections where frost is likely to occur, bud wood should be cut in December and stored until needed. In sections where frost is not likely to occur, the wood for spring budding need not be cut until just before growth starts in the spring, although it is usually best to get it in December, as a frost might occur during the winter and so injure the young growth that bud wood would be difficult to secure. Bud wood cut in December can be saved for summer budding.

After the bud wood has been secured the leaves are cut off and the bud wood cut into lengths of about 1 foot. Care should be taken that bud wood of several varieties of citrus do not become mixed, if bud wood is taken from more than one variety of citrus. If the bud wood has been cut in December it will have to be stored. The best method for storing citrus bud wood is to use rather small boxes that will hold only a small number of buds when packed, three to five thousand being sufficient to place in each box. These boxes should be lined with paper and 2 inches of moderately moist sawdust from cypress shingle mills placed in the bottom. This sawdust is commonly called cypress shingle tow. A thin layer of bud sticks is placed in on the shingle tow and covered with a layer of shingle tow $1\frac{1}{2}$ to 2 inches thick; another layer of bud sticks is then placed on the tow, and the layers of bud sticks and shingle tow alternate until the box is filled, the top layer being shingle tow 3 or 4 inches deep, and this should be covered with paper. The box or a number of boxes can then be stored in a shed or outbuilding. Care must be taken not to have too much moisture in the shingle tow. The proper amount can be learned after a little experience. Packed in this way, well-matured dormant buds may be kept in good condition for several months.

80. The bud is inserted in the stock near the surface of the ground, the exact distance above the ground varying somewhat with the climate and the susceptibility of the stock to foot rot. As the bud union is tender and easily injured by frost, it is advantageous to insert the bud low on the stock in order that earth can be mounded up over it as protection in winter.

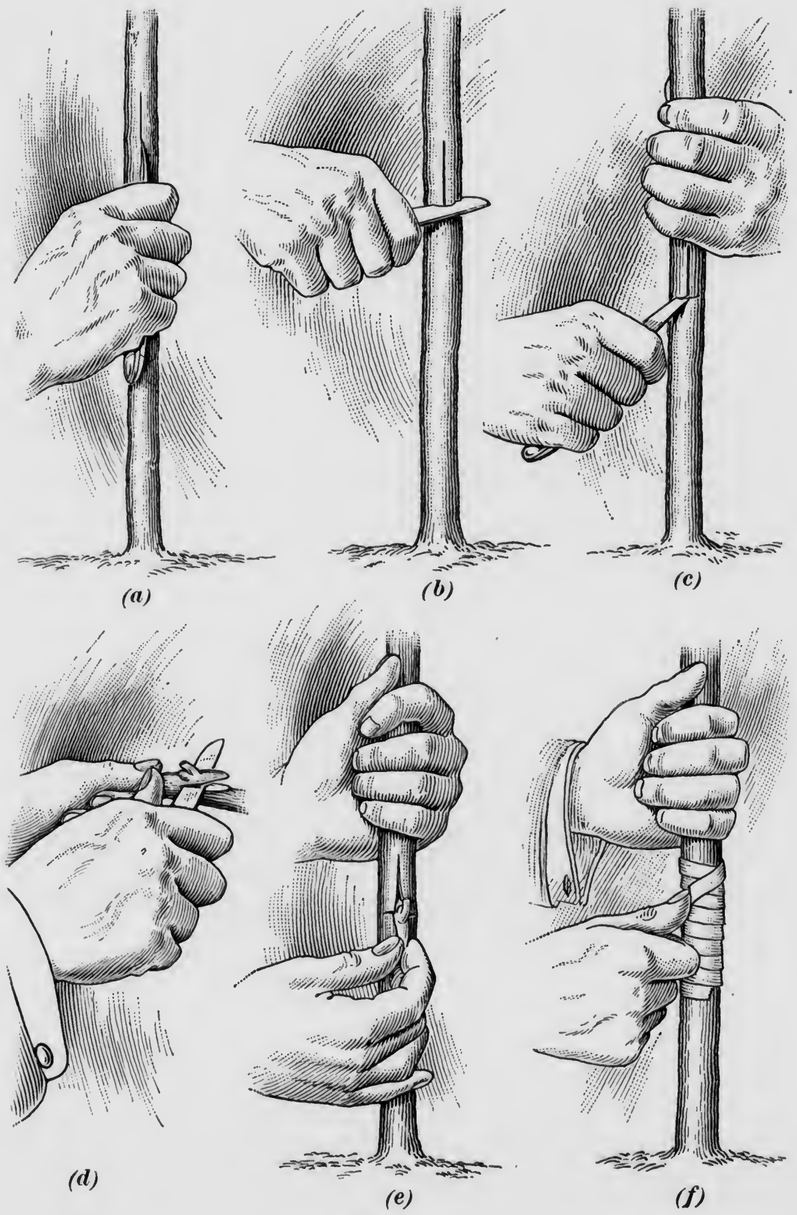

FIG. 20

However, sweet-orange and Mandarin trees are subject to foot rot, and even when budded on sour orange stock that is resistant to this disease, the trees above the bud may be affected if the bud is very near the ground. In practice, the distance that buds are inserted varies all the way from 2 to 18 inches above the ground.

81. The so-called **T**, or shield, method of budding is employed for citrus trees. In the gulf-coast states the cross incision is made at the lower end of the longitudinal cut, differing in this respect from the practice in California and Arizona. In Fig. 20 is shown the various steps of budding a citrus seedling. In (*a*) is shown the downward slit made in the stock; this cut is from 1 inch to $1\frac{1}{2}$ inches in length. In (*b*) is shown the cross incision; the cutting edge of the blade slants upwards when this cut is made. In (*c*) is shown the edges of the bark being lifted with the point of the knife blade. In (*d*) is shown the cut made to remove the bud from the bud stick; in removing the bud the stick is held in one hand with the proximal end—that is, the end that was nearest the limb from which it was taken—away from the body; the cut is started about $\frac{1}{2}$ inch above the bud and finished about $\frac{1}{2}$ inch below it. In (*e*) is shown the bud inserted in the stock; to insert the bud, it is grasped lightly between the thumb and the first finger and shoved upwards into the incision in the stock. The bud should be placed in the same position on the stock as it was on the bud stick. The operator can be sure the bud is in the right position if the leaf stalk, or scar, is toward the ground. In (*f*) is shown the bud wrapped with strips of waxed cloth. The wrapping should commence just below the transverse cut and be continued upwards, each turn overlapping the previous one, and the final turn is made downwards as shown. When wrapped in this way water cannot get to the bud. It is not necessary to tie the strip, as the wax will hold it in place. In wrapping, care should be exercised to keep the sides of the longitudinal cut pressed together.

82. Waxed cloth torn into strips about $\frac{1}{4}$ to $\frac{1}{2}$ inch in width is the material generally used for wrapping the buds. This

material can be prepared by dipping muslin in hot grafting wax. Several formulas are in use for making this wax; all are more or less satisfactory. One that will be found to give good results is 4 pounds of rosin, 2 pounds of beeswax, and 1 pound of tallow or 1 pint of linseed oil. The rosin should be broken and the beeswax cut into small pieces and melted with the tallow or the linseed oil. The piece of muslin is dipped into this hot wax, taken out immediately, and the surplus wax removed before it cools. A convenient way to do this is to place the muslin over a rod as shown in Fig. 21, and then by means of two wooden strips scrape off and squeeze out the surplus wax. The cloth is than spread out to cool, after which it is torn into strips of the desired width. These strips can then be wrapped into balls, and as each new piece is added it is slipped about a half-inch under the end of the strip previously wound, thus making a practically continuous strip.

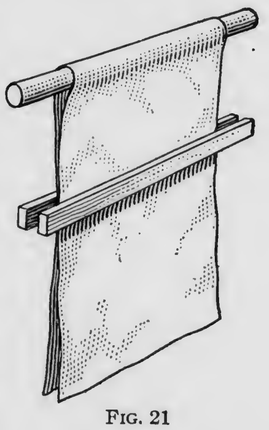

FIG. 21

83. When angled bud wood is used, the bud is removed with a larger piece of bark on one side of the bud than on the other. If the bud were cut without leaving this extra bark on one side there would not be enough cambium layer left on the bud to form a union with the stock. The manner of cutting an angular bud is shown in Fig. 22 (*a*); the severed bud is shown in (*b*). The manner of making the incision in the tree for the bud is shown in (*c*); the bud in position is shown in (*d*). The bud is then wrapped

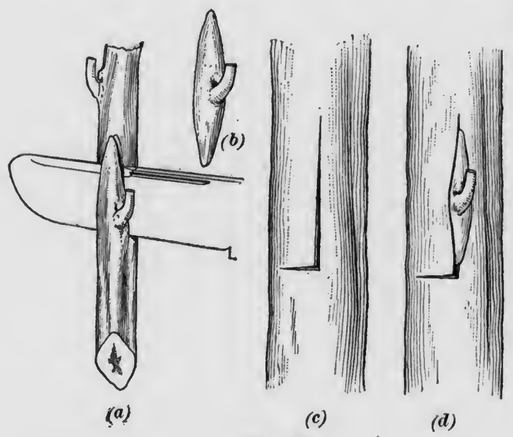

FIG. 22

in the manner shown in Fig. 20 (*f*). The tree, except in the case of dormant budding, should be examined in from 10 days to 2 weeks to see whether the bud and stock have united. If the bud is still green and a grayish line of new tissue can be seen around the edges of the incision, it is likely that a union of bud and stock has taken place. Sometimes, especially in dry weather, the uniting may not take place under 20 days. The wrapping can be removed when the bud has united. Any stocks on which the bud has failed to unite should be rebudded.

84. In order that the bud will be forced into active growth after it has united with the stock, it is necessary to check or in some cases stop the growth of the stock above the bud. This will force the sap from the roots into the bud. In the case of small stocks it is often the practice to remove the tops just above the bud, thus forcing all the sap of the tree into the bud. A stock with the top cut off and a growing bud is shown in Fig. 23. The cut to remove the top should be made with a sharp tool, and it is well to cover the cut surface with paint or some kind of wound dressing. In the case of rather large stocks, it is safer to lop the top than to remove it entirely. The top is lopped by cutting it about two-thirds through in from 3 to 5 days after the wrapping around the bud is removed and then bending it over until it rests on the ground. The cut is generally made about 2 inches above the bud on the same side of the stock as the bud. Care should be taken that the stock does not split and injure the bud. A saw or a pair of pruning shears can be used for making the cut. If shears are used the knife edge is held against the tree on the side where the cut is to be made. The lopped tops of each pair of rows in the nursery should be turned to occupy the space between them.

FIG. 23

Cultivation can then proceed down the row spaces that are not obstructed by the lopped tops. After the buds have grown to about 12 or 18 inches in length, the lopped tops can be removed. When the buds have reached this length, whether they were lopped or not, they should be tied to stakes to prevent them from bending over, and as they continue to grow they should be tied as often as necessary to keep them growing straight, which will usually be three or four times during the season.

Common four-ply cotton twine is most commonly used for tying the trees to the stakes. The stakes should be $\frac{3}{4}$ to 1 inch square, and about 4 feet long. Care should be taken that all sprouts from the stocks below the buds are removed, as well as all undesirable branches that arise along the trunks of the young trees.

When dormant budding is practiced, the tops are not lopped or removed until just before the spring growth starts, which is about the last of February. The process of budding is otherwise the same as for spring or summer budding.

85. Young budded trees in the nursery should receive the same cultivation and watering as described for seedlings. Nurserymen generally prune the trees back occasionally to prevent them from growing too spindly, and they also rub off sprouts that form along the lower part of the stem, as these detract from the growth of the trees. When the trees are a year old from the bud they are known as 1-year-old trees, and often they are planted at this age. At times, however, budded trees 2 years old are planted. There is some difference of opinion as to whether it is better to plant 1-year-old or 2-year-old buds; this is a question that must be settled by the grower.

86. Nurserymen in Florida grade trees, especially 1-year-old budded trees, according to height; the practice in this respect is different from that in California, where the grade of trees is determined by calipering them 1 inch above the bud. The Florida nurserymen, however, often specify what should be the caliper of tree of a given height, and reserve the right to sell either by caliper or by height. Budded trees 2 or 3 years old

are not usually sold according to height, but simply as 2-year-old or 3-year-old buds. Trees budded on Citrus trifoliata stock are more dwarf than those on other stocks, and for this reason smaller trees budded on this stock are often sold.

87. The following price lists from two prominent nurseries of Florida will give a good idea of how nurserymen grade and list trees for sale:

PRICE LIST NO. 1

ORANGES

Grade	*Each*	*Per 10*	*Per 100*	*Per 1,000*
2 to 3 feet	$ .45	$ 4.00	$ 35.00	$320.00
3 to 4 feet	.55	5.00	45.00	420.00
4 to 5 feet	.75	6.50	60.00	550.00
5 to 7 feet	.85	7.50	70.00	650.00
2 years	1.25	11.50	100.00	
GRAPEFRUIT				
2 to 3 feet	$ .60	$ 5.00	$ 45.00	$400.00
3 to 4 feet	.80	7.00	60.00	500.00
4 to 5 feet	1.00	9.00	75.00	650.00
5 to 7 feet	1.30	11.00	90.00	800.00
2 years	1.75	16.00	150.00	

PRICE LIST NO. 2

ORANGES

Grade	*Each*	*Per 10*	*Per 100*	*Per 1,000*
1 to 2 feet	$ .35	$ 3.00	$ 25.00	$ 200.00
2 to 3 feet	.45	4.00	35.00	320.00
3 to 4 feet	.55	5.00	45.00	420.00
4 to 5 feet	.75	6.50	60.00	550.00
5 to 7 feet	.85	7.50	70.00	650.00
2 years	1.75	15.00	125.00	1,000.00
GRAPEFRUIT				
1 to 2 feet	$ .50	$ 4.50	$ 40.00	$ 350.00
2 to 3 feet	.75	6.50	50.00	450.00
3 to 4 feet	1.00	8.50	65.00	600.00
4 to 5 feet	1.50	12.50	85.00	750.00
5 to 7 feet	2.00	15.00	125.00	1,000.00
2 years	3.00	25.00	200.00	1,500.00

88. Securing Nursery Stock.—Whether to purchase citrus nursery stock from nurserymen or to propagate it at home is a problem that confronts the orange grower. There are, of course, arguments in favor of both plans. As may be inferred from the preceding paragraphs, the requirements for growing citrus trees ready for planting are a long time, the right soil and climatic conditions, careful attention to details, and considerable knowledge of tree growth. Most growers do not have land available for a nursery, and hence must depend on nurserymen; and those planting new trees, unless they are adding to groves already established, will not care to wait the 3 or 4 years necessary to produce the trees. When buying from a nurseryman, it is well to deal with one having a reputation for selling good trees. Most dealers give a guarantee to replace any trees that do not come true, but when a grower has waited several years for a tree to produce fruit and then finds the fruit not of the type or variety he purchased he has lost much more than the price of the tree and replacing it is not much of a financial advantage. True, such trees can be budded over to some desired variety, but even this means some loss. Nurserymen, too, being experienced in this particular line of work, can usually produce better trees than the average grower. Their workmen will be more adept in removing the tops and roots, in digging the trees, and, in fact, in all the details of tree production. These facts, coupled with those discussed in the first of the paragraph, often make it advantageous for the grower to purchase his trees ready for planting in the grove.

In case, however, a grower is well established, and has land available for the purpose, and possesses a knowledge of nursery work, he may find it advisable to grow his own trees. The principal advantage, aside from the cost that may under the right conditions be less than were the trees purchased outright, is that the buds can be selected from the best type of tree of the variety it is desired to propagate. A bud from a good-producing, healthy tree is very likely to be a better bud for propagation than one from a tree that produces meager crops of poor fruit. The nurseryman who buds thousands of

trees cannot, as a rule, give as much attention to bud selection as the grower who buds comparatively few trees, and, therefore, the grower, if all other conditions are right, may get trees of slightly better quality than if purchasing from the average nurseryman. Many growers who propagate their own trees often have a surplus which they can sell to their neighbors, thus aiding them somewhat in the expense of growing the trees.

CITRUS FRUITS IN GULF-COAST STATES
(PART 2)

MANAGEMENT OF GROVES

PLANTING AND CARE OF CITRUS TREES

1. Clearing the Land.—In Florida, land that is desirable for citrus trees usually is covered with a growth of virgin timber, or, if it has been cut over for lumber, stumps and second-growth trees remain. One of two plans for clearing the land may be adopted—clearing the land completely, or clearing it partly. The former is, as a rule, to be preferred, but in some sections growers claim that the leaving of a few trees—palmettos on hammock land, for example—is an advantage, as they shield the ground from the rays of the burning sun, and that, therefore, the fruit trees will often do better than if all the forest trees are removed. In Fig. 1 is shown an orange grove near Fort Myers, Florida, where a few palmetto trees are left standing. On pine lands a few trees are often left standing, generally for the purpose of saving expense in clearing. The practice of leaving forest trees is severely condemned by many persons; they contend that the young citrus trees require all of the ground.

If it is decided to clear the land only partly before the trees are set, the space where the trees are to stand should be cleared of all stumps and underbrush. All roots in the soil should be removed to a depth of $1\frac{1}{2}$ or 2 feet over an area sufficiently

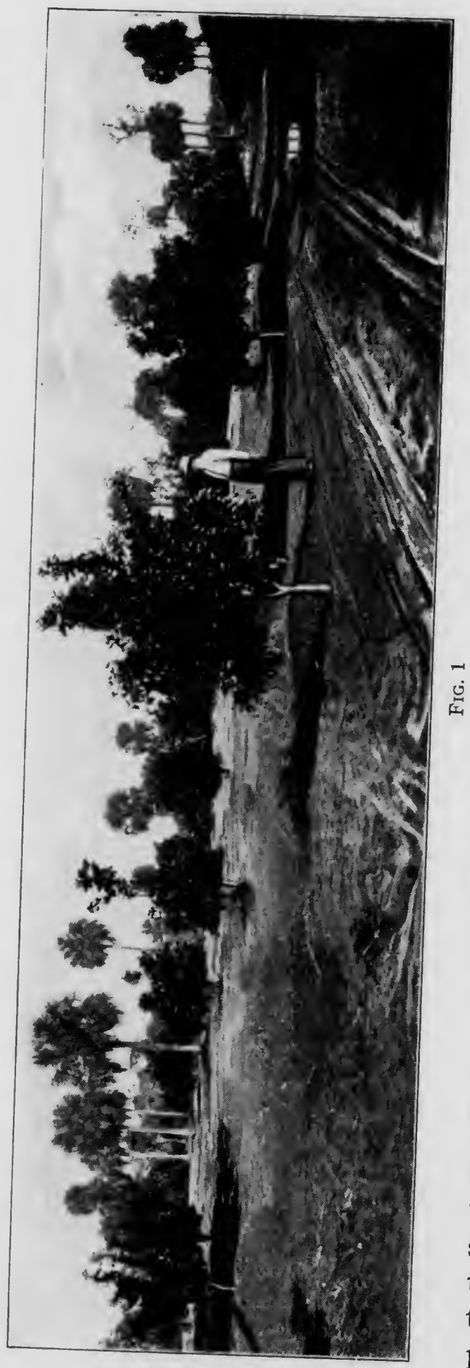

FIG. 1

large that the roots of the citrus trees will have sufficient space to develop without being crowded. If there is a growth of saw palmetto on the ground, considerable grubbing with a mattock will be necessary to remove the roots. Dynamite or a stump puller can often be used advantageously for removing stumps. The timber, stumps, roots, and brush removed can be burned and the ashes spread on the soil, or the larger pieces of wood can be placed in piles and saved for fuel, and the brush, roots, etc., either burned or piled in rows and allowed to rot. The trees that are left standing should be removed before they begin to crowd the young citrus trees and deprive them of plant-food and moisture.

In case it has been decided to clear the land completely, the trees should be cut down and all stumps, brush, and roots removed. The sides of the clearing should be squared up, so that the citrus trees, when they are set, may be readily planted in straight rows.

2. After the timber, stumps, and rubbish have been removed the ground should be plowed, harrowed, and leveled. Newly cleared ground, especially low ground, will generally be somewhat acid. This condition can generally be corrected by plowing the land and leaving the furrows upturned to the sun and then applying lime. In Florida, slaked lime at the rate of 1,000 pounds to the acre is generally used on new ground. Ground limestone at the rate of 1 ton to the acre, if used about 2 years before the grove is planted, has about the same effect and in addition has the advantage of not burning out the humus in the soil. An application of ground bone or basic slag, before the trees are set, will also aid in improving the soil for the growth of citrus trees on account of the plant-food these materials add to the soil.

3. Most growers advise the growing of a cover crop during the summer season previous to setting the trees. Some, however, do not follow this practice, but after plowing, harrowing and leveling the ground, plant the trees and then sow a cover crop between the rows and later turn the plants under. The planting of the ground to a cover crop the season prior to the setting of the trees is advisable, because the roots of the cover crop open up the soil, humus is added to the soil by the plowing under of the crop, and, in the case of legumes, nitrogen is added to the soil. It has been found that citrus trees planted on land after a cover crop was grown will be as far advanced in a few years as trees a year older planted on land that did not have a cover crop grown on it.

If cleared land that has grown a varied number of crops is to be set out to citrus trees, the same general principles apply in preparing the ground as apply in preparing uncleared land for citrus trees. If the previous crops removed from the ground have left the ground low in humus and in an acid condition, then a cover crop should be planted the summer previous to setting the trees, and a good application of lime made, in order to replenish the supply of humus and correct the acidity of the soil. If, however, such unfavorable conditions do not exist in the soil the trees may be planted at once.

4. Before planting the trees, no matter which plan of getting the ground ready has been adopted, the soil should be put in the best of tilth. The soil should be stirred to a fair depth, but not deep enough to bring up subsoil that is particularly deficient in humus. Each person can judge the depth to plow on the land that is being prepared. If the soil below plow depth is firm and compact, a subsoil plow might be run through the furrows to advantage to loosen it. After plowing, a cultivator or harrow followed by a planker or drag should be used to smooth the surface. Too much attention can scarcely be given to getting the ground in good tilth before planting the trees.

5. Season for Planting.—Citrus trees can be planted successfully at any time of the year, provided that the wood of the trunks is firm and that the trees have the proper care in such matters as watering, frost protection, etc. It has been already said that citrus trees are not periodic in their growth. Several growths are made each year, and, as long as the trees are set after the wood has ripened and become firm and hard, they may be planted at almost any season as far as the growth of the tree is concerned. However, on account of climatic conditions, certain seasons of the year in all citrus sections are better than others for the planting of the trees. In Florida, the latter part of December, January, and until about February 15, or in the summer just after the rainy season has started and the soil has become moist, are the two general periods for planting. The former period seems to be the most favorable, however, for during the winter months danger of exposure to sun and wind may be reduced to a minimum, the weather is cool, the soil is moist, and is settled firmly about the tree roots by the winter rains, and the trees will start growth readily on the first warm days of spring. If the planting is done much before December 15, there is likely to be growths started which would be injured by frost during the winter, and if done much after the fifteenth of February, the young trees are likely to be injured by the dry season, which usually starts in March. Earlier planting gives

the trees a start before the dry season begins. The objection to planting during the winter is that the trees may be injured by frost, but this danger can be lessened by banking the trees with clean earth above the bud, and then, in case of a freeze, only the tops will be injured and the trees will grow in the spring the same as if the tops had been pruned off with shears.

Summer planting of citrus trees is successful if trees can be had with firm and hard trunks and sufficient water is provided either by irrigation or by rainfall. Summer-planted trees have a tendency to prolong growth later in the fall than those planted earlier, and as a result they are likely to go into winter in such a succulent condition that even slight frosts will injure them. Thus, there are arguments in favor of all the different seasons, and a grower must, therefore, settle this matter for himself.

6. Arrangement of Trees.—In Florida, most groves are laid out according to the rectangular system. In this system the trees are set out in rectangles that are either square or oblong. There are several advantages in setting trees according to this system: the rows can be laid off very cheaply and easily; the rows intersect each other at right angles, and cultivation can be carried on both ways in the grove, either crosswise or lengthwise; and the trees can be planted equidistant or closer together in the rows than the distance between the rows. There are several other systems of laying out groves, but as the rows in these systems do not intersect at right angles, a grove cannot be so easily cultivated.

7. Distance for Planting.—The distance apart that citrus trees should be planted in a grove is a point on which growers do not agree. In recent years trees have been planted much farther apart than they were formerly, for it has been learned by experience that they require a relatively large amount of space for development. No set distances for planting the trees can be given that will be suitable for all conditions. The distance varies according to the kind and the fertility of the soil, the amount of moisture it is possible

to have in the soil, the kind of stock on which the tree is budded, and the variety of citrus that is planted. Trees under these different conditions vary in the amount of growth that they make and the size they attain. It is also important to have the trees far enough apart that the grove operations, such as spraying, cultivating, etc., can be carried on conveniently.

In Florida, sweet oranges and grapefruit are frequently planted in rows 30 feet apart, or in some cases the rows are 35 feet apart, and the trees are 25 feet apart in the rows. Many growers also plant the trees in squares, with the trees 30 feet apart each way. In the Atwood grove at Manavista, grapefruit trees are planted in rows 30 feet apart and the trees are 15 feet apart in the rows. Many growers are adopting this plan of rather close planting, some with the idea in mind of cutting out every other tree in the row when the trees are such a size that they crowd too much. Others state that for grapefruit the trees should not be removed, as they will not be damaged even if they do become crowded.

In other gulf-coast states—Mississippi, Alabama, and Texas—the distances of planting are somewhat closer than in Florida. Here the Satsuma orange, which is a Mandarin orange, is the most largely planted variety of citrus. The distance between the trees ranges from 14 to 18 feet. Sweet oranges are usually planted 20 feet apart. Pomelos are planted about 20 feet apart each way. One prominent grower in Texas formerly planted oranges, grapefruit, and lemons 20 feet apart each way, but has found by experience that closer planting is desirable and is now planting citrus trees 15 feet apart in the row and the rows 18 feet apart.

The following distances of planting for the various varieties of citrus represent the greatest and the smallest distance apart that the trees are usually planted commercially: Kumquats, 10 to 15 feet; pomelos, 15 to 30 feet, the most common distances, however, being 20 to 30 feet; lemons, 20 to 25 feet; limes, 15 to 20 feet; Mandarin oranges, 14 to 20 feet, the most common distance being 17 to 18 feet; sweet oranges, 20 to 30 feet, the most common distance being 20 to 25 feet.

8. Planting Varieties in Blocks.—If more than one variety of citrus fruits are grown it is well to plant the different varieties in blocks by themselves. Most of the prominent commercial varieties mature at different seasons and for this reason the fruits can be harvested from one block when the fruit is in season without traversing areas in the groves in which the fruits are not ripe or areas from which the fruit has already been harvested.

9. Crops in the Grove.—Frequently some crop is grown in the grove between the trees while they are young and do not require all the space. Such crops increase the financial return from the young grove and in some cases pay for the care of the grove before the trees come into profitable bearing.

Some other kind of fruit trees are sometimes set out with the citrus trees, with the idea of cutting them out as soon as they get large enough to crowd the citrus trees, which are to grow to maturity. The citrus trees are known as permanent trees, and the trees that are to be removed before they come to maturity are known as fillers. A good example of this practice is found in the planting of peaches with citrus trees. This is sometimes done in the higher lands of Florida where peaches do fairly well. The peach trees are allowed to remain until three or four peach crops have been harvested and then they are cut out. In Louisiana, the Satsuma orange is sometimes used as a filler for pecans. The pecans are planted 60 feet apart and the Satsuma orange in planted between the pecan trees. It is doubtful whether this is a commendable practice, for the Satsuma orange tree is a relatively long-lived tree and is thought by some growers to be more profitable than the pecan tree. The planting of some other kind of fruit tree as a filler between citrus trees is not so common as in deciduous fruit planting.

Intercropping with some vegetables, small fruits, or with pineapples is a more common practice than the planting of fruit trees between the rows. Care should be exercised, if such crops are planted, not to use a fertilizer for them that would be injurious to the citrus trees. Die-back, a disease

of citrus trees, is often caused by the overstimulating of the trees with organic plant-food, and this disease has often been known to occur in groves where vegetables were grown between the rows.

10. Laying Out Groves.—After the ground has been well prepared and the sides of the area to be planted are squared up, a stake should be set where each tree will stand. The

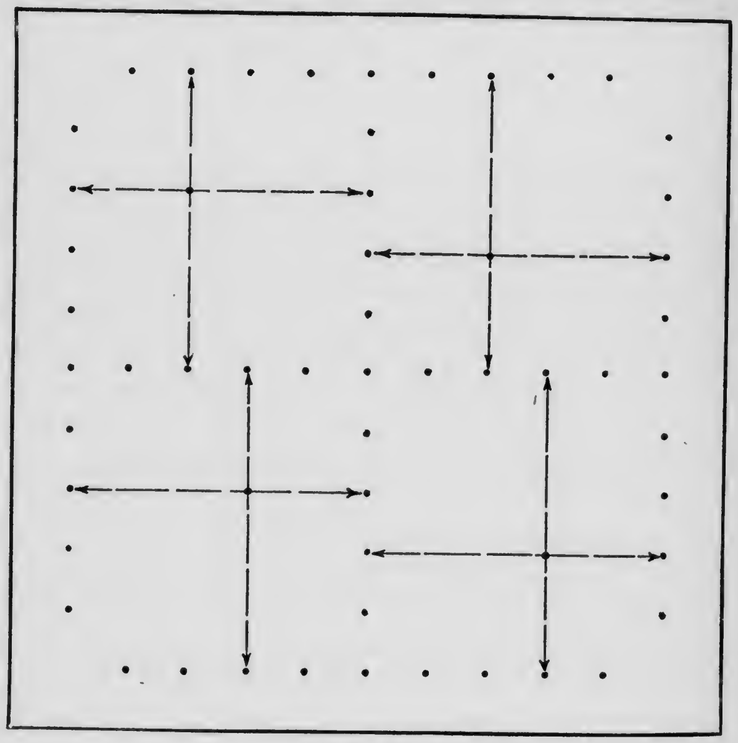

FIG. 2

surest method of securing absolutely straight rows in a grove is to have a surveyor locate the position of every tree, and this is sometimes done where the question of appearance is of sufficient importance to justify such an expensive method. In many cases, however, the expense of this method will be prohibitive. One of the most convenient methods of securing straight rows in rectangular planting without surveying the grove is to locate the outside rows around the field carefully,

and then set a row of stakes with one stake where each tree is to be located in these rows around the field. If the lines of the field are definitely known, a man's judgment will suggest a way to get these stakes in the right place. Then, through the center of the field in each direction, another row of stakes is set as shown in Fig. 2. Common plaster laths make good stakes.

With a field laid out in this way there are always two stakes available in two directions for determining the proper location for each tree to be planted. For example, the proper location for a tree may be determined by sighting across stakes as indicated by the lines in Fig. 2. The usual method is to set a stake at the point where each tree should go, as determined by sighting; but since the stake must be removed when the hole for the tree is dug, a planting board is commonly used to get each tree in its proper place. In Fig. 3 is shown a planting board by means of which a tree can be planted exactly where the stake stood originally. The dimensions are marked for the convenience of those wishing to saw out such a board; *a*, *a* are the stakes locating where the trees are to stand; *b* is the planting board with the square notch at the center in place at the position of one of the stakes *a*; *c*, *c* are two stakes that are placed in the end notches of the board. Assuming that the ground has been prepared and staked, the planting board is placed in turn over each stake where a tree is to stand; two stakes corresponding to *c*, *c* are placed in position as shown in the illustration, and the stake *a* is removed. This leaves a row of stakes on either side of where the tree row will stand. Holes for the trees are then dug, and when a tree is to be set the planting board is placed over each pair of stakes so that the trunk occupies the same position on the board as the

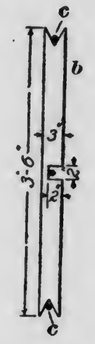

FIG. 3

stake *a* did when the board was placed in position previous to the removing of the stakes. If the land is at all inclined to have a hard subsoil, it is a good plan to use a stick of dynamite in digging each hole. This will loosen up the ground and give the roots an opportunity to go down more deeply into the soil. If dynamite is used in loosening the soil, care should be taken that the earth has settled thoroughly in the bottom of the hole and that all air spaces formed in the cavity have been filled with soil. If the soil settles considerably after the tree has been set, the result will be that the tree will be in the soil too deep for the best conditions of growth.

11. Treatment of Young Trees Before Planting.—If the young trees come from a nursery, they will arrive packed

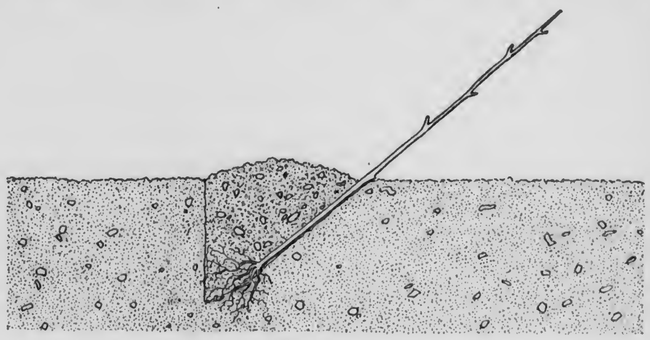

FIG. 4

in boxes or bales. These should be opened as soon as received and the trees either planted at once or heeled in to prevent the roots from drying out. A piece of wet burlap thrown over the roots even for the short time while transferring them to the ground will often prevent many roots from drying out. The aim of the planter when handling young trees should be to prevent the drying out of the roots. When heeling in citrus trees, a shady, well-drained place should be selected, and a furrow of sufficient length to accommodate all of the trees when spread out side by side should be plowed out. This furrow should then be sloped on one side to an angle of about 45 degrees, and the trees placed along the slanting side. The furrow is then filled with earth, which is packed firmly about

the roots, after which the soil is watered immediately. Fig. 4 shows a cross-section through a row of heeled-in nursery trees.

When conditions are right for the planting, the trees should be removed from the trench, bale, or box a few at a time as needed. The roots should be trimmed, and all broken, abraded, or otherwise injured roots removed. A sharp knife should be used for this purpose, and the cut should be made from the under side. A smooth cut will heal and callous over much more quickly than a ragged one. As soon as the roots have been trimmed the trees should be covered with damp burlap or a wet blanket in order to prevent drying out. It is important that the roots are not exposed to the sun rays or to winds. The trees should then be carried to the field.

12. The holes in which the trees are to be set should preferably not be dug until a short time before the trees are to be planted, as the soil about the trees will then be moist and therefore in a better condition for the growth of the trees. The holes should be dug somewhat deeper than necessary to receive the tree roots, and they should be wide enough to permit ample spreading out of the roots. Some surface soil should then be placed in the bottom of the hole; many growers advocate mixing at the time of planting about 1 pound of what is termed grower fertilizer with this surface soil. Others claim they get better results by spreading some fertilizer on the ground where the tree will stand, and working it well into the soil about a month before the trees are planted.

13. With the planting board in place over the hole to indicate where a tree is to be, a good rule to follow in planting the tree is to set it in the hole so that the crown roots are brought up tightly against the under side of the planting board, care being taken that the planting board is not placed in a dip or depression in the ground. This allows the tree to settle sufficiently and still not stand any deeper than it did in the nursery. Trees should never stand deeper than they stood in the nursery for they do not make a good growth if planted too deeply.

The roots are then spread out and the surface soil that is thrown in the hole first is worked about them with the hands, care being taken that the soil is packed firmly about the roots. Dirt is filled into the hole until it is about full, and the tree watered. About 3 or 4 gallons of water are needed to wet the soil thoroughly. Some planters use a tank with a hose attached for watering during planting; others simply use a pail and dip the water from a barrel hauled about the grove. After watering, the hole is filled with earth and another 3 to 5 gallons of water poured about the trees. Enough water must be applied to make a mush of the soil. Some planters make a cup-shaped ridge about 2 feet in diameter around the base of the tree to hold the water. Moss, grass, or dry sand is placed over the wet earth to hold the moisture.

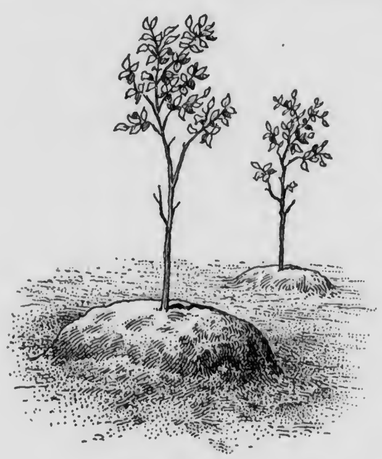

FIG. 5

14. On sites that are not well drained or on shallow soils it is sometimes a practice to plant the trees on mounds and then gradually work the ground back into the spaces between the trees, eventually leaving the trees standing on slight mounds. This practice improves the drainage of the soil about the trees and often prevents the tree roots from standing in water-logged soil. The mounds are made circular about 4 feet across and 1 foot or less in height and are level on top. The tree when set on a mound should have the ends of the tap roots about even with the surface of the ground below the mound. The mound usually consists largely of surface soil, with which a little fertilizer has been mixed. Fig. 5 illustrates young trees planted on mounds. An idea of the shape and size of the mounds can be gained from a study of this picture.

15. As soon as the trees are planted the tops should be pruned back commensurate with the pruning that the roots

received. It must be remembered that when young trees are transplanted, more than 50 per cent. of their roots are removed in lifting them from the ground and in pruning them before they are planted. The top must be pruned accordingly, that a proper balance may be maintained between the roots and the top. It is true that nurserymen defoliate the trees and cut them back considerably before they are shipped, but this is seldom sufficient, and the grower should usually remove more of the top. In Florida, defoliation is required by state nursery inspectors for the purpose of preventing the transfer from place to place of insect pests that can be carried on the leaves.

Young trees that have been grown to a single stem should have the top cut off just above a node, the distance above the ground depending on the preference of the grower. Lateral branches should then be allowed to form as well distributed as possible around the main stem in a vertical space of 9 to 12 inches down from the top. All undesirable branches should then be rubbed off after growth starts. Growers do not agree on the height that trees should be cut back, some preferring them cut back to a height of $1\frac{1}{2}$ to 2 feet and others preferring them cut back to a height of from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet from the ground. However, there are advantages in having low-headed trees in that the fruit can be harvested more easily and the trees are less apt to be injured by the wind.

If well-developed branches are found on the young trees, such as are commonly found on 2- and 3-year-old trees, undesirable branches should be cut off and the others cut back to spurs with two or three buds on them. If the trees do not start into growth soon after being planted, it is a pretty good indication that they are still out of balance, and that it is necessary to cut the tops back still more severely.

16. After trees are set in a grove, it is a good plan to make a map of the grove and locate on it the positions of the different varieties. Such a map saves considerable time in locating the trees of the various varieties and will be a valuable asset to the grower if he at any time desires to sell the grove. A map of this kind should be drawn with ink on architect's

glazed muslin and should be of a size that will permit of it being conveniently carried in the grove.

17. Watering of Young Trees.—If dry weather follows the planting of trees, they will need an occasional watering for the first few months after they are set. About 3 or 4 gallons each time will probably be necessary, except in very sandy soils, where the quantity may need to be somewhat increased. The conditions of the trees is an index of when water is needed.

18. Cultivation of Newly-Set Groves.—Directly after the trees are planted, if there is no rain, the ground should be cultivated. It is important that moisture be retained in the soil for the needs of the trees, and this can be accomplished only by frequent cultivations. The water makes its way to the surface of the soil by capillary attraction through small spaces between the soil particles. These spaces connect into irregular tubes. If these tubes extend to the surface of the soil, as they do when no cultivation is given, the moisture is drawn to the surface where it is lost to the soil by evaporation. Cultivation breaks up these capillary tubes and exposes the surface soil to such an extent that it parts with much of its moisture and becomes very dry. The soil then forms a dust mulch over the soil beneath, making it more difficult for the moisture to be drawn off by evaporation.

19. Implements of Tillage.—Largely because of the light sandy nature of the soil found in most citrus groves in Florida, fewer tillage implements are required than in most other citrus sections. A plow, one or possibly two harrows, and occasionally an orchard cultivator are the implements usually found in a citrus grove in Florida.

Several so-called orange plows of the moldboard type are sold in the Florida citrus districts. These are designed especially to turn a shallow furrow in a sandy soil. Naturally, growers differ in their choice of plows, some preferring one type and others a different type. In Fig. 6 are shown several types of plows that from a careful canvass of the opinions of Florida growers seem to be general favorites. The plow in (*a*)

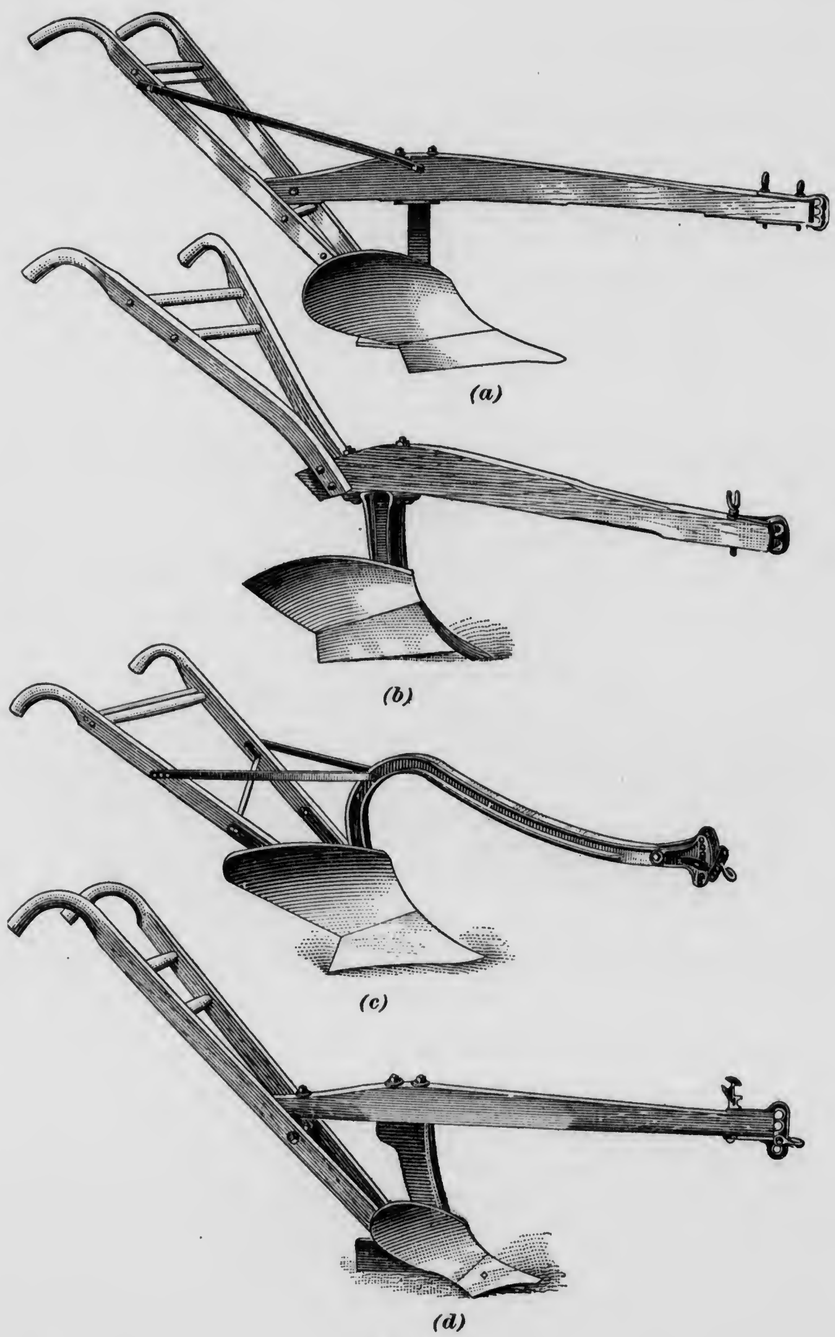

FIG. 6

is known as the Avery orange plow, and is claimed by the manufacturers to be light but strong and to work well in light soils, and to be easily adjusted for shallow plowing. In (*b*) is shown the Brindley orange plow, which is provided with what is known as a duck-bill point. This plow is designed for shallow plowing in sandy soil, and it is claimed will turn the furrow completely over and cover all grass, weeds, etc. In (*c*) is illustrated the Deere sandy soil plow, with an iron beam. This is also made with a wooden beam. Like the others, it is designed for use in sandy soils, and by many growers it is considered to be one of the best. In (*d*) is shown a one-horse orange plow known as the Chattanooga one-horse sandy land

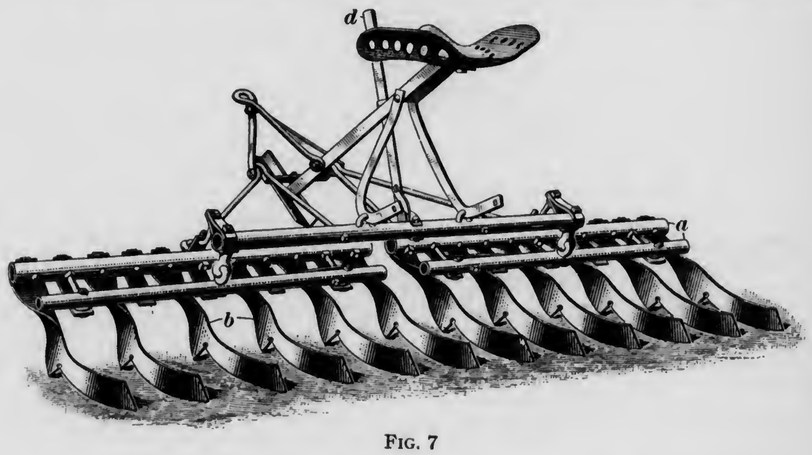

FIG. 7

plow. Like the two-horse plows described, it is designed to turn a shallow furrow in sandy soil.

20. The harrow most used in the groves is the Acme, one of which is shown in Fig. 7. This harrow is built in sections, each section having six or eight blades, or colters, *b*, which are bolted on iron bars, or pipes, *a*. The illustration shows two sections of six blades each, which is a convenient size for a two-horse team, but it can be separated so that each section can be operated by a single horse, or several sections may be added as may be convenient. The blades of this harrow are from 15 to 18 inches long and from $2\frac{1}{2}$ to 3 inches wide. They have a backward slope and are beveled and ground to an edge.

By means of the lever *d* it is possible to adjust the angle at which the blades work, so that they will cut to as great a depth as 4 inches or simply work in the top 2 inches of soil. For a smoothing and leveling implement, this harrow works very well in the soils of the gulf-coast states, and is very effective in making a dust mulch to conserve moisture in dry weather.

The disk type of harrow, one of which is shown in Fig. 8, is used to some extent in groves for cutting clods and working a cover crop into the soil. The excessive use of an Acme

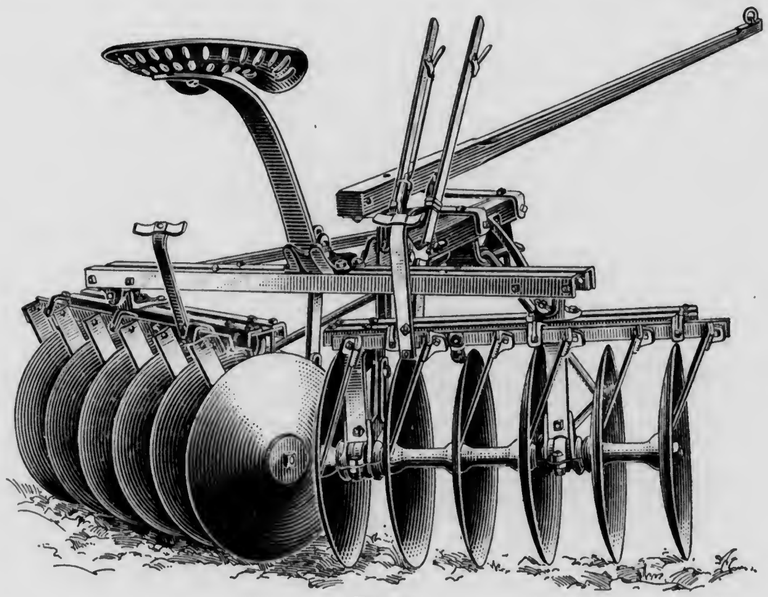

FIG. 8

harrow has a tendency to pack a layer of soil beneath the surface. A disk harrow run over the ground once will break this up and improve the condition of the soil. For the cultivation of the soil in groves, it is desirable to have an extension disk harrow, which can be opened out, or extended, to permit of cultivation under low branches.

Cultivators of the Iron Age, or the Planet Jr., type are used to a limited extent for cultivating groves in Florida. If a grove has been neglected and the soil needs a thorough working deeper than can be conveniently given with an Acme harrow,

a cultivator of this type is an excellent implement to use on the ground. Figs. 9 and 10 show a cultivator of this type. When cultivating at some distance from the trees the seat is attached as shown in Fig. 9, and when cultivating close to the trees the seat is shifted to the position shown in Fig. 10. By means of the levers the teeth can be set to dig at different depths.

21. Systems of Handling the Soil in the Grove.—Soils and climatic conditions differ so much that not all groves can be handled in the same manner, consequently each grower

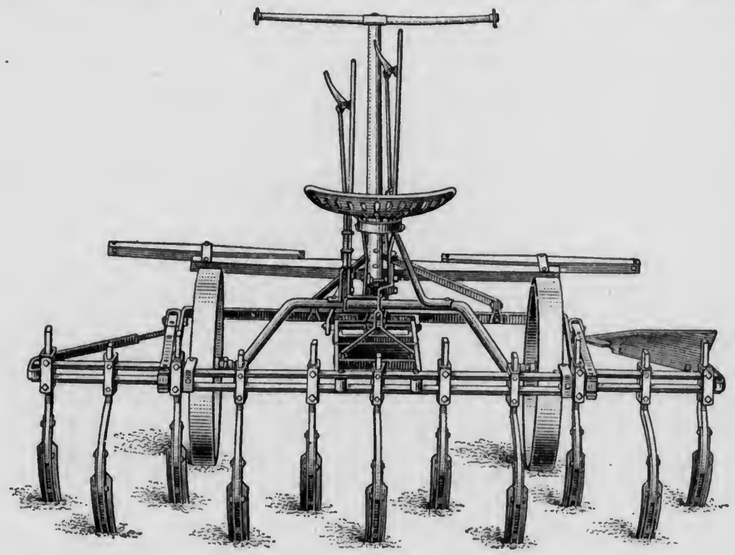

FIG. 9

must decide for himself just how he will care for his soil. The principal objects of every system of soil management should be to save for the use of the trees as large a proportion as possible of the rainfall, to add some humus to the soil, and at the same time to make more available the original content of plant-food in the soil.

22. Clean Culture with Cover-Crop System.—In the clean culture with cover-crop system of management the general practice is to keep the ground clean by frequent cultivations from the time the ground is plowed or disked in the

fall or winter until the beginning of the rainy season about the first of June, when the cover crop is sown.

In the sandy soils of the gulf-coast states the plowing should be no deeper than necessary to turn the ground over and bury the cover crop under the furrow slice. Citrus trees are shallow feeders, and deep tillage means a loss of many small fibrous roots. In fact, some good managers never plow the soil in the groves, but depend entirely on the disk harrow and other harrows for all their cultivating operations.

Cultivation should follow immediately after the plowing of the soil and should be continued up to the rainy season in

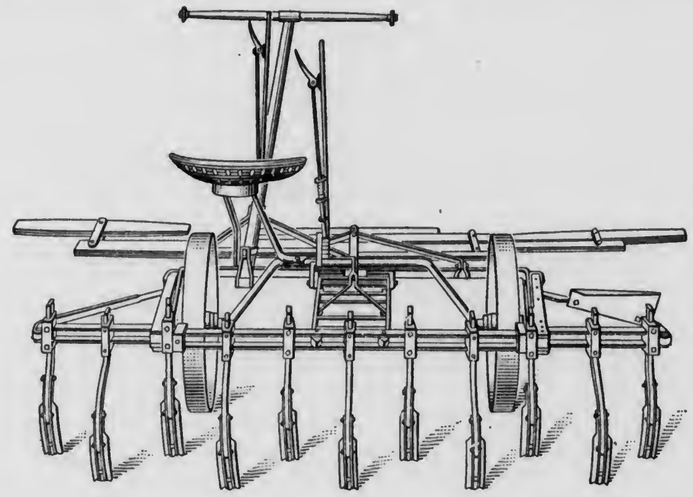

FIG. 10

June or until the cover crop is sown. A disk harrow is sometimes used after plowing on soils that are inclined to be heavy and occasionally during the year, but in most groves, especially those in which the soil is sandy, the Acme harrow if used often enough will keep the soil in good condition.

23. The frequency of cultivation depends somewhat on the weather. As the principal advantage of cultivation is the conservation of moisture, the ground should be worked more frequently during a dry period than during a wet period. It is a good plan, provided it is the time of the year when it is desirable to prevent the loss of moisture from the soil,

to go over the ground after every rain as soon as the soil dries out sufficiently to permit of cultivation. A good general rule to follow is to go over the grove with the Acme harrow every 10 days during the time moisture should be saved in the soil. In fact, it is well to keep the harrow going constantly, and as soon as the work is finished on one side of the grove to begin on the other. It is impossible to cultivate too often during the dry season.

As with the plowing, all cultivation of the soil should be shallow. However, slight variation in depth of cultivation is sometimes advisable to break up a packed layer of soil beneath the surface, but even this does not mean that any one cultivation needs to be excessively deep. The use of a cultivator of the type shown in Figs. 9 and 10 on ground that has been worked frequently will break up this packed layer, if the teeth of the cultivator are set to run just a little deeper than the blades of the harrow went into the soil.

24. The exact time of discontinuing cultivation and sowing the cover crop will vary with different growers and in accordance with the season, the section where the grove is located, and the weather. The general time to turn the grove loose—that is, stop the cultivation and plant the cover crop—is just before the rainy season. The cover crop is allowed to grow until the following fall or early winter, when it is turned under for the purpose of adding humus to the soil. The exact time of plowing under the cover crop will also vary with the grower and with the season. October is the usual month for plowing under cover crops in Florida, although many growers wait until December or even January. An advantage of plowing early, however, is that the foliage is out of the way during the picking season, and the trees are apt to pass the winter in better condition if the ground is broken and cleanly cultivated; also, during the cold weather of winter, when fires in the groves may be necessary for the protection of the trees and fruit from frost, there is no trash on the ground that can catch on fire and thus cause damage to the grove. In the light soils of the gulf-coast states the cover crops should not be

plowed under while they are green and succulent, but rather after they are dry and partly rotted. The plowing under of a too succulent growth in these soils makes an acid condition of soil that is unfavorable for the growth of citrus trees. In case the crop is still green when it is desired to plow the groves the plants can be cut with a mowing machine and allowed to lie on the surface until they dry and partly decay before the ground is plowed.

25. A cover crop may be secured by sowing seeds of various legumes or grasses or by permitting native grasses, such as crab grass, or weeds to come up voluntarily. During the rainy season when the ground is left uncultivated, an abundant growth of these volunteer crops will cover the ground and provide a liberal amount of vegetable matter to be turned under; in fact, they frequently produce a larger amount of vegetable matter than a seeded cover crop. Some growers rely on a crop of this kind entirely for a cover crop. However, such crops do not collect nitrogen, and when they are returned to the soil give back only that which they have withdrawn. They add fiber to the soil, increasing the humus content, and thus have an ameliorating effect on the soil. It is more desirable that some legume crop be sown, since it will increase the nitrogen as well as the humus content of the soil. For this reason legumes are used very generally as cover crops in groves of the gulf-coast states.

The velvet bean, beggarweed, and cowpea are the principal legumes planted, some growers preferring one and others preferring another. Which variety of plant to grow as a cover crop is a question that must be decided by each individual grower. The climatic conditions of the region where the grove is located, the condition of the soil, and whether or not the plant does well in the locality, cost of seeding per acre, the amount of vegetable matter produced for turning under, and the ability of the plant to increase the amount of nitrogen in the soil are factors to consider.

26. Velvet beans for cover crops in citrus groves can be planted any time from the middle or last of April to not later

than the last of May; the earlier they are planted the better. The seeds can be sown broadcast, but it is better to plant them in drills or in hills. If planted in drills, the rows should be 4 feet apart and the seeds 2 feet apart in the rows. If planted in hills, the hills should be about 4 feet apart each way, and four beans placed in each hill. An area 6 or 8 feet wide should be left unplanted on each side of the tree row. About ¼ bushel of seed will plant an acre of grove. Since the beans are somewhat slow in starting growth, the ground can be cultivated a few times after the seeds are planted. This is an advantage, as it keeps down weeds until the bean plants become established.

The velvet bean makes a very dense growth and care must be taken that the vines do not get into the trees; if they come in contact with the branches they will entwine about them and become a nuisance. Some growers plant two or three rows of corn among the beans. This provides stems on which the vines can climb, and hence it serves to keep them out of the trees.

During the summer and early fall the vines make a luxuriant growth. In the northern part of the gulf-coast region early frosts will kill many of them, and several inches of dead vines and leaves will cover the ground. In the central and southern sections of Florida it is necessary to cut the vines early in the fall with a mowing machine and allow them to die before plowing them under.

27. Beggarweed is a strong-growing annual plant that is native to Florida. It does well in all parts of the state and in some sections of the other gulf-coast states. Beggarweed when once planted will reseed itself and come up every year, provided it is not cut too early in the season for it to produce seed. The seeds are sown broadcast between the tree rows about the middle of May and are harrowed well into the soil. From 6 to 8 pounds of seed are required per acre. The ground can be cultivated for a short time after the seeds are sown, but this will mainly have to be confined to the tree rows, and cultivation be one way, so that the young plants of beggarweed will be undisturbed in the middles between the tree rows.

After the first season when the plants have become established and plenty of seed has been scattered over the ground, the grove can be freely cultivated from the time the ground is plowed in the fall until it is desired to have the cover crop grow in the summer. As soon as cultivation ceases the beggarweed will come up all through the grove.

During the summer the plants will make a good growth. The crop should be cut when it first comes into bloom in the season. If sufficient stubble is left, it will shoot out and produce another good crop. Care should be taken that the first crop is not cut too early in the season, for on many soils it will be so green and succulent that it will not produce a good second crop. Sometimes two or more cuttings can be made in the same season. Each cutting should preferably be allowed to decay on the surface of the ground. Sometimes the plants are left to grow for the whole season and in the fall are torn loose from the ground with a corn-stalk breaker. Either a cutaway or a disk harrow will incorporate the beggarweed into the soil.

28. Cowpeas are sometimes used for cover crops in Florida citrus groves, especially in young groves, but, unfortunately, the plants are subject to the action of nematode worms that produce root knot. However, the Braham and Iron varieties have been found fairly resistant to root knot in the South, and for this reason these varieties are recommended for planting where it is desired to grow cowpeas. The seed can be sown broadcast a week or so before the last cultivation of the grove. The plants will make a luxuriant growth during the summer, and in the early fall they should be cut with a mowing machine, in order that the stems will be dry before the crop is plowed under. Cowpeas are most largely planted as a cover crop in the other gulf-coast states.

29. No-Cultivation System.—In contrast to the cultivation with the cover-crop system of soil management there is what may be termed the no-cultivation system. In this system the ground is not cultivated at all, the grass and weeds that spring up being simply mowed and left on the ground.

As a general rule, however, it can be said that most groves can be handled to the best advantage by the previously mentioned system, although on low hammock soils in Florida, where moisture is very abundant even during a dry season, this no-cultivation system can often be used to advantage.

30. Flat-Hoeing System.—What may be called the flat-hoeing system of grove management is practiced by some growers in Florida. All tillage work in the groves is done by hand, hoes being used to cultivate the ground. Shallow cultivation of the soil is practiced and all the soil of the grove, including that near the tree trunks, is cultivated. The ground is kept cleanly cultivated during the winter and spring months, and volunteer crops are allowed to grow during the summer and fall and this vegetable matter is incorporated with the soil by hoeing in the spring. Mr. L. B. Knox, of Ormond, Florida, manages his groves this way and has very good results. His conditions, however, make the plan succeed; whereas, in other groves the practicability of this system would be doubtful. Many of the trees of this grove are budded on mature sour-orange roots and the budded trees are in the same places that the native wild trees stood; hence, they are irregularly placed. In this particular section the trees do not seem to grow so large as in some other sections of the state, and for this reason they are left closer together than citrus trees are usually planted. Thus, the irregularity of the trees on the ground and their nearness together make the cultivation of the soil with horse-drawn implements less practicable than in groves where the trees are spaced at uniform distances, and are the usual distance apart. Mr. Knox grows much fancy fruit for which he receives high prices, and this is another reason why he can use hand labor instead of horse-drawn implements for cultivating his grove.

31. Fertilizer Mulch System.—The fertilizer mulch system of grove management is advocated and practiced to some extent by some growers in Florida. In this system clean cultivation with cover crops is practiced until the trees are

from 7 to 10 years old. After that time grass is allowed to grow and remain on the ground the year round. The grass is mowed in the fall and is not removed from the grove. Fertilizer is applied at certain times during the season, as the trees require plant-food. In a later part of this Section the kinds of fertilizer used in citrus groves and the amounts and times for application are given, and the statements made there will apply here as well.

Among the advantages claimed for this system is that the fruit is smoother and of finer quality than if the ground is tilled during a part of the year. This has not been satisfactorily proved, however, but some few grove owners are experimenting with the system in hopes of finding out its advantages and disadvantages.

PRUNING OF CITRUS TREES

32. Citrus trees, with the exception of lemons, as grown in California, require less pruning than any other class of fruit trees. This fact has led many growers to believe that the trees require no pruning at all. Most of the pruning is done when the trees are set out, and very little subsequent pruning is given. For this reason, it is important that the pruning at this time be done in such a way that heavy pruning may be avoided later. Branches that will be undesirable on the tree when it becomes older should not be allowed to develop. Although an orange or a grapefruit tree, if not injured by frost or attacked by some insect pest or disease, will usually make a productive tree without much pruning if it has the right kind of care, yet experience has proved that a certain amount of pruning at certain times will be a benefit. In the gulf-coast states the foliage of citrus trees should be sufficiently dense to exclude the sun from the interior of the tree. Large openings in the head of the tree should be avoided. For this reason it is important that all branches that are likely to be undesirable should be removed when the trees are small. Heavy pruning invariably results in a heavy growth of water sprouts and the

interior of the tree will become as dense as before. In addition, the removal of too much wood at any one time may cause die-back, a disease of citrus trees prevalent in many southern groves.

The trunk and main branches of citrus trees should be shaded from the direct rays of the sun, or many branches will die as a result of exposure to excessive heat. The limbs of citrus trees should be strong in order to support a heavy crop of foliage and fruit, and, for this reason, should have sufficient space for development. Suckers will grow out from the interior of a tree, and these should be removed unless they are wanted to fill out some open space in the tree. Fruiting branches can eventually be formed from these suckers by pruning back the ends. Unless desired for filling in spaces, suckers are undesirable; they take much plant-food and moisture that otherwise might be of use to the fruiting branches of the trees. Another reason why suckers should be removed is that, on account of their succulency, they are especially liable to be attacked by the citrus white fly and thus spread this pest to other parts of the tree.

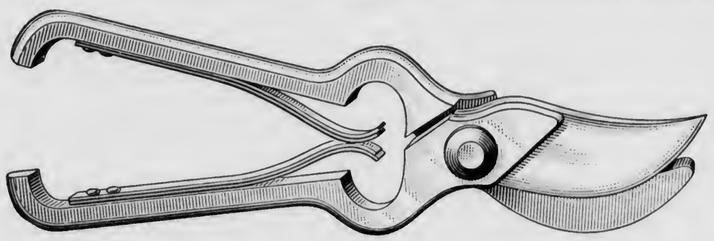

FIG. 11

All dead and decaying wood should be removed from citrus trees, for such wood harbors fungous growths that are likely to infest fruit and healthy branches and foliage. For example, the fungus that causes melanose and stem-end rot occurs in decaying wood. The fact that all dead and decaying wood should be removed from citrus trees cannot be too strongly emphasized. Many trees have died and much fruit has been lost in the past on account of dead wood having been allowed to remain on the trees. When removing a partly decayed branch it is well to cut back to healthy wood in order to be

sure that all infected areas have been removed. Often infected areas exist beyond the region of apparently dead wood. All decayed twigs and branches should be removed from the grove and burned to prevent further infection.

A good time for pruning trees is when they are dormant. Usually the work is done during some dormant period in the winter or in the spring after the crop has been removed. At this time many branches that may have been injured by the weight of fruit can be removed, and since the soil is likely to be in clean cultivation, the prunings can be removed easily without interference with the cover crop. In pruning citrus trees, however, a good rule to follow is "prune whenever you see something that should come off."

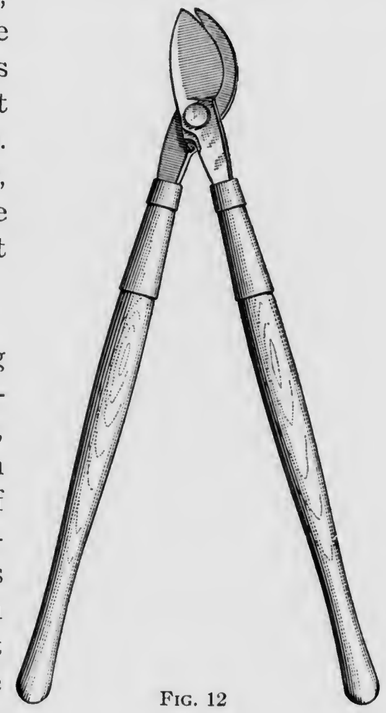

FIG. 12

33. The tools used for pruning are hand pruning shears, long-handled shears, a pruning knife, and saws. Shears like those shown in Fig. 11 are used to take off small twigs and suckers; long-handled shears, known often as lopping shears, like the pair shown in Fig. 12, are used for pruning out branches in the interior of a tree and branches that are too large to be cut with hand shears. Several types of saws are used for pruning citrus trees. The saw shown in Fig. 13 has a swivel blade which makes it possible to saw at any angle desired, and is a desirable saw for pruning the larger limbs of citrus trees. All pruning tools should be kept well sharpened in order that clean cuts can be made. Often it is economical for the pruner to stop work and get the shears and saws sharpened. In making a cut with shears, the cutting edge should always be held toward the part that is to remain on the tree.

This means a clean cut and but little stub left on the tree. All cuts should be made as near as possible to the branch or

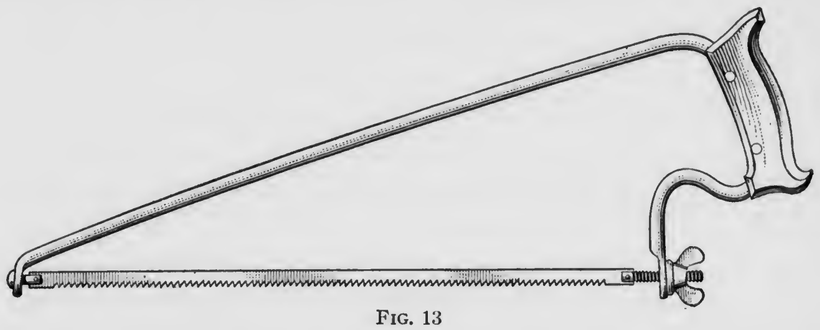

FIG. 13

limb remaining on the tree. If a cut is made close to a branch or trunk, the wound will soon heal over; if a stub is left the tree cannot heal the wound, and the wood of the exposed stub soon decays, and decay will continue into the trunk or

FIG. 14

branch on which the stub is located, thus injuring the tree. In Fig. 14 is shown the effect of the right and the wrong ways

of removing branches from citrus trees; *a* is a stub that was left in pruning, and it will be seen that the tree has not been able to heal the wound; *b* is a branch that was removed but no stub left, and, as a result, the wound was healed; *c* is a small wound that will soon heal.

Some kind of wound dressing should be used on the cut surface whenever a branch is removed. Many preparations are used for covering wounds, among which may be mentioned warm coal tar, grafting wax applied with a brush, and good white-lead paint with sufficient color in it to make it inconspicuous.

Much of the work of pruning can be done from the ground, but step ladders should be used when necessary to get at the higher branches. Regular picking ladders that lean against the trees are not very satisfactory as pruning ladders because they are likely to break the branches.

FERTILIZATION OF GROVES

34. Lack of fruitfulness in citrus trees is frequently due to lack of sufficient plant-food in the soil. Cultivation has a tendency to make more available the plant-food that is in the soil. Cover crops also help to increase the plant-food content of the soil. With few exceptions, however, these two factors alone do not make available sufficient plant-food in the soil for satisfactory results. The soil in the gulf-coast states adapted to citrus fruit culture is thin and light and requires fertilizer for the production of satisfactory crops of fruit. Some soils may contain sufficient plant-food to supply the needs of the trees for some time, but sooner or later they will become exhausted and then applications of fertilizer must be made if the trees are to continue in profitable bearing. Other soils are so light and sandy that fertilizers will have to be used from the time the young trees are planted.

The use of fertilizers is largely a local problem with the grower. It is impossible to give a fertilizer formula that will be adapted to all soils for all conditions of growth. The

fertilizer to use will vary with the kind of soil, the management of the grove, whether or not cover crops are turned under, the cultivation that is given, the age of the trees, and, in fact, many other local factors. It is important that the grower acquaint himself with the various kinds of fertilizers used in groves and experiment with them, using them in varying amounts and combinations, and keep accurate records of results. In this way valuable data can be obtained that pertains to his own grove. Practical information can be gained by talking with the best growers in the vicinity, but it is well to have the opinions of several such growers, because each individual is likely to favor the use of a certain fertilizer for no valid reason other than a personal preference. In addition, much good information can be had from fertilizer dealers. In Florida, some of the best concerns selling fertilizer have experts who travel throughout the state and advise growers about their fertilizer problems. When getting information from such men, however, it should be remembered that they are working for fertilizer concerns and that it is the business of their firms to sell fertilizer. Still, this advice, coupled with that gained otherwise, will usually enable a grower to come to a wise decision about the fertilizer to use for his grove.

35. It is claimed by many horticulturists and growers that for Florida conditions, barnyard manure should not be used as a fertilizer in citrus groves in that state, because it produces a rank growth of foliage, injures the quality of the fruit, and frequently causes die-back. However, the Alabama Experiment Station recommends for conditions in their state the use of manure in the fall after the trees are planted, the manure being spaded in the soil not too close to the trees.

The elements necessary for plant growth that are usually lacking in the soil are nitrogen, potassium, and phosphorus. Plants require many other chemical elements in the course of their growth, but these other elements are almost always present in the soil in sufficient quantities.

It may be said that nitrogen is useful to the tree in making a large growth of new wood. An abundant supply of nitrogen

in the soil is indicated by a dark-green, glossy foliage. Lack of nitrogen is indicated by a yellowing of the leaves and a sickly, stunted growth of leaves and twigs. Excess of nitrogen in the soil retards the maturity of the fruit and causes the fruits to form thick, puffy rinds, and too much rag.

The requisite amount of phosphorus in the soil causes the fruit to develop properly, and a plentiful supply hastens the maturity of the fruit. Potassium is valuable in the soil for the assistance it gives in the physiological process of plant growth, enabling the leaves to take up carbon from the atmosphere. Citrus fruits grown on soils that have liberal amounts of available potassium in them have thinner skins and a less amount of rag than trees that are grown in soils deficient in potassium. The proper supply of potassium seems to have a beneficial effect on the keeping quality of the fruit. Trees plentifully supplied with this food also form firm, hard wood that withstands cold and wind more than trees grown on soils deficient in potassium.

36. Sources of the Essential Plant-Foods.—Nitrogen may be obtained from nitrate of soda, sulphate of ammonia, cottonseed meal, tankage, and dried blood. The first two materials are most used as sources of nitrogen for citrus trees. The nitrate of soda is the quickest acting source of nitrogen that can be used; the sulphate of ammonia is slower in its action. Also, the continued use of sulphate of ammonia will cause the loss of lime in the soil, and tend to make the soil acid. In case the soil becomes acid it will be necessary to apply lime in order to counteract this effect. Cottonseed meal, tankage, and dried blood are organic fertilizers and are not very often used as sources of nitrogen for citrus trees. Organic fertilizers are not only slower in their action but in some sections their application is followed by die-back, a disease of citrus trees.

The sources of phosphorus are bone, phosphatic rock, and basic slag, frequently known as Thomas phosphate powder. The bone is sold as ground, steamed, or dissolved, bone. The phosphatic rock is treated with acid, in order to make the

phosphorus available and is sold under the trade name of acid phosphate. It has been claimed by some growers that it is better to use dissolved bone as a source of phosphorus in preference to acid phosphate, yet, acid phosphate has been used continuously for several years in some groves in Florida with satisfactory results. Basic slag, or Thomas phosphate powder, is frequently used by people who mix their own fertilizers, as a source of phosphorus, and, although it is very slow acting, some growers have used it successfully.

Potassium can be purchased either as sulphate of potash, muriate of potash, or kainit. The latter is a mixture of potassium salts, largely in the sulphate forms. Sulphate of potash is the most used source of potassium for citrus groves. The muriate is supposed to have a bad effect on citrus trees and for this reason is largely avoided. Kainit is used by some growers with fair results.

37. Fertilizer for Citrus Trees.—Nursery trees and young trees in the grove that have not come into bearing require a different fertilizer treatment than trees that are bearing fruit. For young trees the fertilizer should be richer in nitrogen and poorer in phosphorus and potassium than for bearing trees. This is obvious when it is considered that abundant nitrogen is necessary for the growth of wood and foliage, just what is desired in young trees, and that abundant phosphorus and potassium are necessary to produce ripened fruit of good quality, with thin skins, little rag, and good keeping quality, conditions sought in bearing trees. No absolute formulas, either for non-bearing or for bearing trees, can be given that will apply to all conditions, but there are general formulas for each class that can be modified to suit specific conditions. The time of application makes a difference in the proportions of plant-foods used in the fertilizer formula. A fertilizer applied in spring and summer should be richer in nitrogen than a fertilizer applied in the fall, because a fertilizer rich in nitrogen used in the fall is likely to send the trees into the winter with a succulent growth that is easily injured even by light frosts.

38. A general formula for nursery stock and young trees for use in the spring or summer is one containing 4 per cent. of nitrogen, 6 per cent. of phosphoric acid, and 8 per cent. of potash. This formula should, of course, be modified to suit local conditions. If the soil is fairly rich in humus and nitrogen the percentage of nitrogen might be decreased to 3 or $3\frac{1}{2}$ per cent.; if it is very poor in humus and the trees indicate a lack of nitrogen, the nitrogen might be increased to 5 per cent. If the soil is very sandy and deficient in phosphorus the phosphoric acid might be raised to, say, 8 per cent. in the formula, or, under some conditions, if the soil has sufficient phosphorus in it, it might be cut down to about 4 per cent. The potash content might also be changed, with a range of 4 per cent. to 9 per cent., depending on soil conditions. A grower is always safe, however, in applying liberal amounts of phosphorus and potassium, especially in Florida, for the soils in this state as a whole are deficient in these plant-foods. For fall application for young trees, the nitrogen content should be lessened; often it is well to cut it down to 2 or 3 per cent., as the trees will then have an opportunity to harden their wood before winter.

The fertilizer used for nursery stock and young trees, on account of its large proportion of nitrogen, is known among growers as grower fertilizer.

For bearing trees for spring and summer application, a general formula is $3\frac{1}{2}$ per cent. of nitrogen, 8 per cent. of phosphoric acid, and 12 per cent. of potash, but here again there is likely to be the need of wide variation. If the trees by their appearance do not seem to require much nitrogen, the amount may be cut down to, say, 3 per cent., or if, on the contrary, they seem to be suffering for the want of nitrogen, the fertilizer might be made to contain 4 or $4\frac{1}{2}$ per cent. of this element; the amount of phosphoric acid ranges from about 6 to 10 per cent., and of potash from about 8 to 13 per cent., depending on the previous treatment the soil has received and the quantity of fruit on the trees. For fall application the nitrogen percentage of fertilizer used for bearing trees is often reduced to 2 or $2\frac{1}{2}$ per cent.

Many growers buy the ingredients and mix their own fertilizers, and others buy the ready-mixed fertilizers. Often it is economy to mix the ingredients on the farm, and another advantage of home mixing is that it is easy to increase or decrease the quantities of the various elements for the various trees or areas of the grove. However, many growers find it so much more convenient to purchase the goods ready mixed that they order them in this condition from the dealers. Fertilizer dealers have for sale many brands of fertilizer for citrus trees, and they will in addition, if the grower desires, prepare special mixtures to suit his demands.

39. Time for Fertilizing.—A good rule to follow as to the time of applying fertilizer is to put it on the ground when the condition of the tree demands it. Experience shows that the same quantity applied in several applications is better than the whole lot applied at one time. In Florida, the general practice is to make three applications from early spring to late fall, but some growers have found that, especially for young trees, a larger number of applications have given better results. The general times when three applications are made are: (1) in early spring just before growth starts; (2) just before the rainy season in summer; (3) from November 15 to December 15. For young trees, four or even five applications from just before growth starts until September or October are often made with good results. In this matter of the seasons and frequency of application, a grower should experiment in his own grove and be governed accordingly.

40. Quantity of Fertilizer.—Especially in Florida, where the soils are so likely to be deficient in plant-food, observation teaches that the growers who get best results are those who fertilize liberally. This does not mean that fertilizer should be wasted, but that ample quantities should be used. It is possible, however, to use too much fertilizer, especially for young trees. If, for example, the young trees begin to show signs of die-back, which is usually indicated by excessively large leaves, the trouble may be that they are getting too much

food, especially nitrogen, and therefore, nitrogenous fertilizer should be withheld for a time.

For trees the first season they are set out the usual application is from 1 to 2 pounds of fertilizer per tree per year. The amounts are increased about a pound each year up to 5 years. After the fifth year the amount is governed largely by the crop. For a 6- or a 7-year-old tree, from 6 to 8 or even 10 pounds may be used. For 10-year-old trees the quantity will be from 15 to 20 pounds. As the trees become older the quantities are increased, until for a large tree, say one 20 to 30 years old, from 30 to 50 pounds may be necessary.

41. Method of Application.—The fertilizer should be spread evenly on the surface of the ground and worked into the soil by means of tillage implements. Many growers spread the fertilizer by hand, but others make use of fertilizer distributors. A good point to remember when fertilizing a grove is that the roots spread out in the ground about as far as the foliage spreads in the air. The fertilizer, therefore, to be available for all of the roots, should be spread over the entire surface of the ground above them. This means that when the trees are young the fertilizer can be confined to a space near the tree, but when the trees are mature practically all of the ground of the grove should receive fertilizer. Care should be taken that the fertilizer does not come within more than 2 feet of the trunks of the trees, on account of its injurious effects on the crown roots.

SPRAYING OF CITRUS TREES

42. A detail of grove management that should not be neglected in citrus culture is the spraying of the trees to control the ravages of insect and fungous pests. Most efficient managers consider spraying as an investment and not as an expense. In subsequent Sections the principal citrus pests are described and control methods given; growers will find it to their advantage to be familiar with these control measures and to practice them whenever necessary, for it is only by

constantly fighting the pests that they can be controlled. In California and Arizona fumigation of the trees with hydrocyanic-acid gas holds most of the serious insect pests in check, but in the gulf-coast states spraying seems to be the most practical way of combating them.

Both insecticides and fungicides are necessary in spraying work. Many growers buy the materials and mix their own sprays; others use proprietary insecticides and fungicides. In addition to insecticides and fungicides, certain parasitic fungi, usually known as friendly fungi, are sometimes sprayed on the trees. These fungi, of which there are several kinds, help to control many injurious insects. More specific information regarding them is given in a later Section.

All spraying, to be effective, must be done thoroughly. Several sprayings are likely to be required each year, and a grower cannot afford to neglect any of them. The trees should be accessible from all sides, and the workmen should be cautioned to get the material on all parts of the tree. For small groves, hand pumps mounted on a barrel are satisfactory, but growers with large acreages find the power sprayers more satisfactory. The gasoline-engine type of power sprayer is the most popular. Carbonic-acid gas and compressed-air power sprayers are also recommended by many growers. Most any kind of equipment desired can be purchased, and a person just starting into the business of growing citrus fruit will have no trouble in getting a desirable outfit.

IRRIGATION OF GROVES

43. Growers consider irrigation a means of insuring the citrus crop. When the supply of water is inadequate, the trees do not produce good crops, and what fruit is produced is not of good quality. Often there will be several years when the rainfall is so distributed that practically no irrigation is necessary. Then may come a year in which there is a season of prolonged drought, when the trees in the grove, unless they are irrigated, will suffer for the want of water. In Florida

the period during which rainfall is uncertain is from the first of March to the first or middle of June, although in some years rainfall may be very deficient in other months. In order that they may be prepared for drought, many growers make provision for watering their groves. The systems of irrigation employed are much less expensive and more simple in construction than those used in the groves of California and Arizona where irrigation is practiced extensively. Nevertheless, they must be of such a nature that water may be supplied whenever it is required.

44. Where artesian wells are available they are often used as a means of supplying water for irrigation purposes. However, some growers claim that the water from artesian wells, on account of the minerals it contains, is injurious to citrus trees; others use the water freely and notice no injurious effect. In order to control the water from an artesian well, a pipe that can be opened or closed with a wheel valve is sunk into the ground. In Fig. 15 is shown an artesian well in a citrus grove near Fort Myers, Florida. When water is desired for irrigation purposes the wheel valve is opened and the water conducted through open furrows to the parts of the grove to be irrigated.

FIG. 15

Where artesian wells are not available, water for irrigating purposes must, of course, be pumped to the groves from a lake, a river, or a well. Sometimes it is pumped directly to the grove through pipes, but often a storage tank is provided into which the water is pumped and the water then conducted by gravity from this tank to the grove. Each grower will have his own problem when putting in such an irrigation system, and it will pay him to give the matter considerable

attention and devise a system that will provide an ample supply of water when it is required.

45. Water can be distributed through a grove by several methods. The open-furrow method is one of the most common; it consists in carrying the water through open furrows to where it is desired. Many growers make only one furrow midway between each tree row and conduct the water through this furrow. A grove irrigated by the one-furrow method is shown in Fig. 16. Since the soil on which citrus trees are planted in the gulf-coast states is of a sandy nature, much water will soak into the ground even from one furrow, and when water is used, as the growers say, "just to keep off the wilt," one furrow will suffice. When a more thorough irrigation is desired, more furrows are used. Sometimes, when more furrows are desired, furrows are run at right angles to the furrows between the rows. In this case the water is turned into the furrows running one way in the grove, and then later these furrows are closed and the water turned into those that run at right angles.

FIG. 16

In Fig. 17 is shown a section of the Drennen grove near Orlando, Florida, where three furrows are used, two zigzag furrows and an approximately straight furrow between the two.

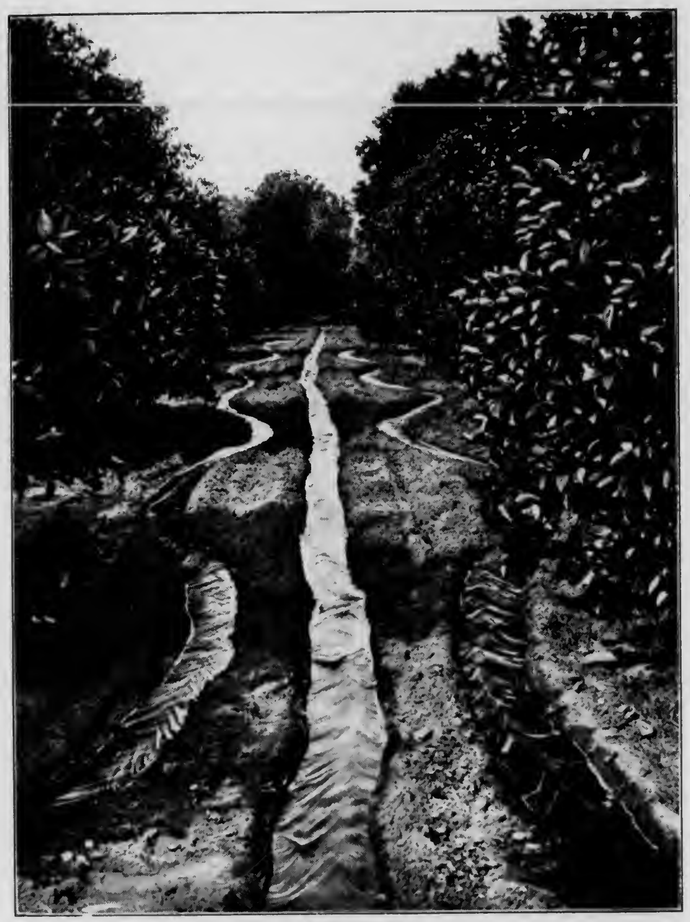

FIG. 17

FIG. 18

275—24

One advantage of the zigzag furrows is that the water requires a longer time to pass through them than through straight furrows, and hence the soil will absorb more moisture. An additional advantage is that the water can be carried for some distance into the spaces between the trees in the rows. In Fig. 18 is shown a section of the same grove where four straight furrows between each two rows of trees are being used to carry the water through the grove. Figs. 17 and 18 were made from photographs taken by the United States Department of Agriculture when an investigation of irrigation practices in Florida groves was made.

In some groves the water is conducted through pipes, and to these are connected spraying stands that are provided with nozzles. The stands are made of short pieces of pipe set near the trees and the water is delivered in the form of a spray. Some growers bury the pipes and others simply lay them on the surface of the ground.

BUDDING OVER TREES

46. Often it is desirable to bud over a mature tree in a grove. The variety may not be a profitable one, or it may be desired to change the tree from an orange to grapefruit, or vice versa. Many successful growers have found it very profitable to bud over their trees. For example, suppose the trees in the grove are of a midseason variety of orange that usually reaches the market at a time when oranges are plentiful and prices low. In such a case it would likely pay the owner to bud over the trees to, say, the Valencia Late, the fruit of which variety usually reaches the market at a time when prices are good.

When budding over an old tree, it is well at first to bud only a few branches and allow the others to grow as usual for a time, and then later, after the first buds have made a fair growth, bud the other branches. If all the branches were budded at one time, it would cause an unbalanced condition between the roots and top and injury to the tree would likely result.

47. Two general methods are followed in budding large branches. In the first of these methods, the limb to be budded is sawed off, and after sprouts have formed and become about $\frac{1}{2}$ inch in diameter, the buds are inserted into two or three of these sprouts in the same way as when nursery trees are budded. The other sprouts are then removed. If all three buds take, growers generally remove one and leave only two to develop. The other method of budding a large limb, and the one most often employed, is to insert the buds into the bark of the limb itself. Usually two buds are inserted, and after they have reached a fair size the limb is lopped in the same way as when nursery trees are budded. In Fig. 19 is shown at *a*, *a* two sprouts from buds that were inserted into a large limb. At *b* and *c* are shown limbs that have been lopped; *b* is the limb in which the buds *a* were inserted; the sprouts on the limb *c* cannot be seen in the illustration. The purpose of lopping the limbs is twofold: it prevents the carrying of too much sap into the growing bud, and also, since the limb is still attached to the tree, any fruit on it will develop and can be harvested. In Fig. 20 is shown at *a*, *a* two buds that have grown into limbs. The

FIG. 19

limb in which the buds were inserted in this case was sawed off at *b*.

In the second method, that of inserting a bud into a mature limb, a curved incision is made as shown in Fig. 21. An incision of this kind is made because of the difficulty of lifting the bark without having it break or crack, as is frequently the case when the regular inverted **T** incision is used. The incision can be made to curve to the right or to the left as desired. The bud is cut with a large shield of bark on the right or the left of the eye, according to the direction of the curve of the incision. The bark of the limb is lifted at the middle of the curve and the shield of bark on the bud shoved underneath it until the eye of the bud is about even with the curve. The bud is then wrapped in the manner described for **T** budding.

FIG. 20

The budding over of large limbs can be done at any season of the year when the bark will slip well; that is, during any period of growth.

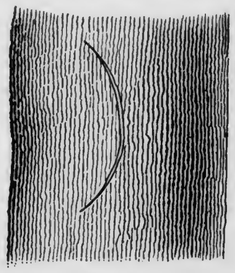

FIG. 21

BRACING LIMBS OF TREES

48. Citrus trees heavily loaded with fruit often need to be braced is some manner to keep the fruit off the ground and to prevent the branches from breaking. Particularly is this the case when they have not been properly pruned. It is often possible to strengthen the framework of a tree by growing a natural crotch brace in the tree. This is done by grafting a

twig located on a branch where a brace is desired to a twig on another branch similarly located. The bark is cut lengthwise on each twig at the point where they come in contact and the two twigs are then wrapped together with budding cloth at the point where the two twigs come in contact. They will soon unite, after which the cloth is removed and the ends of the twigs above the union cut away. These limbs, as

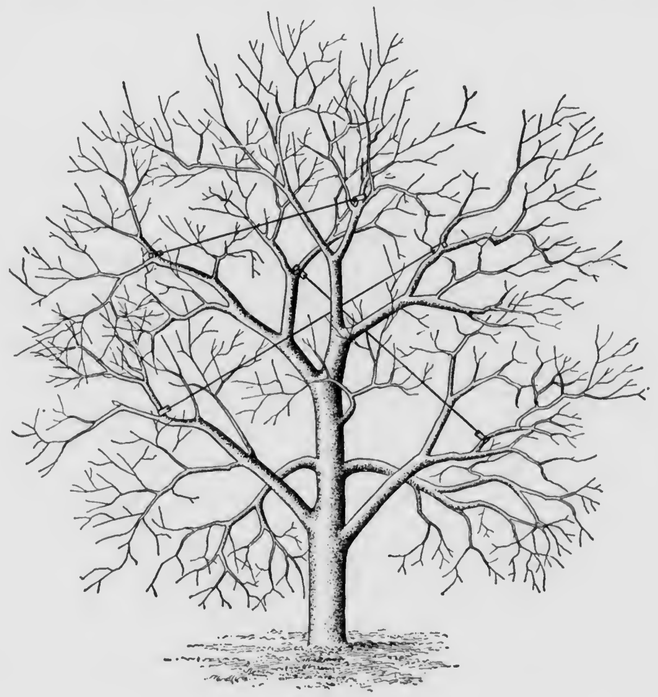

FIG. 22

growth proceeds, will become firmly fastened together, and if they have been well chosen will help to brace the tree.

In California trees are braced in the manner illustrated in Fig. 22, and a few Florida growers are adopting the method. The brace consists of two hooks, like the one shown in Fig. 23, which are hooked into the branches and connected by a wire. These braces are strong and durable and will hold up heavily-laden limbs.

Props are often used for holding loaded limbs off the ground. The prop used in Florida is usually a $3'' \times 1''$ piece of wood cut

the length desired and notched at the top. The props are placed underneath the tree and the limbs are allowed to rest in the notch. A piece of burlap is usually placed in the notch to act as a pad to prevent rubbing of the bark. A disadvantage of such props is that they are not adjustable to limbs of different heights.

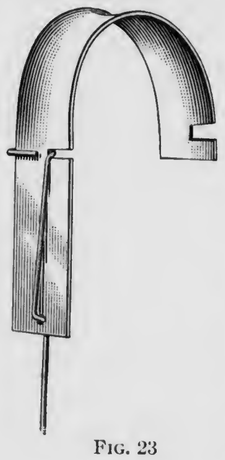

FIG. 23

Fig. 24 illustrates another style of prop used in California. A wire hook is clamped to this as shown and the limbs rest in these hooks as illustrated in Fig. 25. An advantage of this style of prop is that the hook can be placed at any height desired.

FIG. 24

PROTECTION OF TREES AGAINST FROST

49. Since citrus trees are frequently subject to injury by frost, it is important that a grower be prepared to protect the trees when the necessity arises. The principal methods of protection practiced in the gulf-coast states are the mounding of earth about the trunk to protect the bud union, the burning of wood fires in the grove during a period of cold, and the burning of oil or coal in heaters made for this purpose.

50. Mounding to Protect the Bud Union.—The principal reason for protecting the bud union during cold weather is that this is the tenderest part of the tree, and further, if a tree is killed by frost above the bud union, sprouts that come out later above the bud will be of the same variety as the bud, whereas if the bud is killed and sprouts come from below the bud union they will be of the same variety as the stock. In citrus sections in which there is a likelihood of frost most growers mound their trees, but in sections in which there is little likelihood of frost this precaution is not so generally taken.

When mounding the trees, the earth should be thrown well up above the bud union in order to protect not only the bud union, but as much of the trunk as possible. In the case of young trees, however, it is best not to cover the entire trunk, for if they are mounded too high some of the functions of the trees are interfered with and injury may result. The soil will settle somewhat, and for this reason it is well to place more soil on the mounds about 3 or 4 weeks after they are first made. The soil used in making mounds should be free from grass, weeds, etc., as wood lice may cause damage if too much vegetation is present. On low hammock lands that are rich in humus it is a good plan to haul the earth for the mounds from some outside source where it can be had comparatively free from vegetable matter.

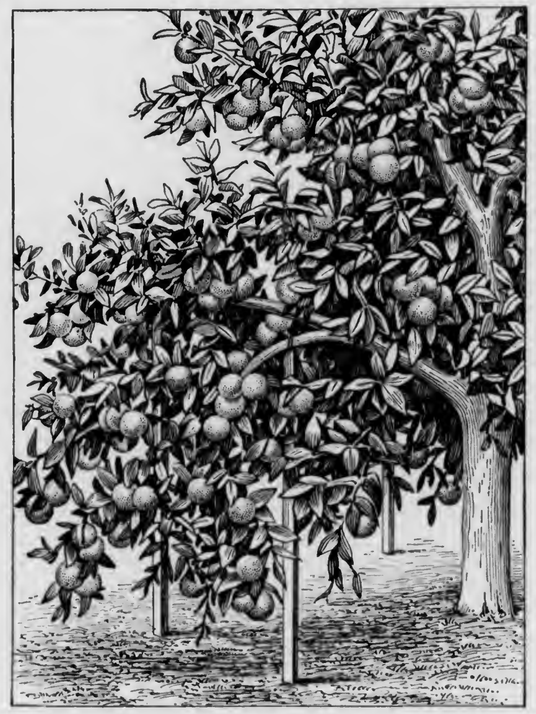

FIG. 25

The first or second week in November is a good time to mound the trees, as no frost is likely to occur before this date. If the trees are mounded after a frost the bark of the trunk is likely to rot during the winter. The soil should be removed from around the trees in the spring as soon as danger from frost has passed; this is usually about the end of March. It is not a good plan to leave the mound about the trees during the summer, as maldigoma disease may attack the trunk above the bud union and cause the death of the tree.

51. Wood Fires for Frost Protection.—A method frequently employed in some sections for the protection of citrus fruit and trees from frost injury is the burning of wood in the grove. What is known as fat pine is good wood for this purpose, as it is full of rosin, ignites readily, and burns with considerable heat. In Fig. 26 is shown a Florida grove with piles of wood in place between the tree rows ready for

FIG. 26

burning. There is much difference in the size of wood used by different growers. Some use logs, which are lighted at one end of the pile, and the logs, as the ends are consumed, are moved over the bed of hot coals; others use smaller pieces of wood and replenish the supply when necessary.

Many growers keep a supply of wood at a convenient place near the grove; and early in the fall before any frost is likely to occur it is placed in the rows between the trees. One pile of wood for every square of four trees is usually provided,

and additional piles are placed around the grove about the same distance apart as the piles between the rows. This will usually be sufficient to protect the trees in a grove, but in extremely cold weather there may be some injury.

The fires should be lighted in a grove just as soon as there is danger of frost, and they should be kept burning until the danger is past. A small quantity of kerosene poured over the wood will aid in igniting it. It is important to keep a sufficient reserve supply of wood where it will be readily available.

52. Orchard Heaters.—In recent years orchard heaters that burn oil or coal have been very successfully used for the protection of citrus groves from frost. The oil-burning heaters seem to have met with the most favor, but some growers have found the coal heaters satisfactory. Orchard heaters have been used to a greater extent in California and Arizona than in the gulf-coast states. In the Western States the results have been very satisfactory when the fires were kept burning until danger of injury was past.

The heating of orchards in California by means of coal and oil heaters was discussed in a previous Section, and what was said there need not be repeated.

HARVESTING AND MARKETING OF CITRUS FRUIT

53. It is generally conceded that the methods used in harvesting and marketing the crop have about as much influence on the profits realized as the methods of growing. Methods of handling the crop have changed greatly in recent years. Those who desire to realize the greatest profit from their fruit are obliged to adopt up-to-date methods, by means of which it is possible to handle the largest quantity of fruit in the best order and with the least possible cost.

54. Season for Picking.—The time for picking fruit is, of course, when it is ripe and ready for market. In the descriptions of the varieties of citrus fruits given in a previous Section the season of ripening for each variety is given; by noting

these times it will be learned that Florida fruit is on the market from October or November until May or June. In the other gulf-coast states where the Satsuma orange is largely grown the season is usually from October to the middle of January.

FIG. 27

The tendency in the past has been to pick some of the earlier varieties and place them on the market before they were fully ripe, but of recent years the government has ruled that under the pure-food law such fruit is misbranded. The state of Florida has also made laws about this matter, and as a result of both the government and the state law, the shipping of immature fruit is not practiced so much at present as it was in the past.

55. Need of Careful Handling of Fruit.—Although an orange or a grapefruit does not show an injury as quickly as do most other kinds of fruit, nevertheless citrus fruits are easily injured by careless handling. Too much attention cannot be given to the proper handling of the fruit when removing it from the tree. Bruises, clipper cuts, fingernail scratches, and all such injuries cause premature decay of the fruit and, in addition, they detract from the appearance and make it sell for a less price than uninjured fruit. The best growers are continually on the lookout for improved methods and equipment for handling the fruit, including picking receptacles, fruit clippers, wagons, and all such appliances that will lessen the chance of damaging the fruit. Many growers require pickers to wear cotton gloves to prevent the fingernails from scratching the fruit.

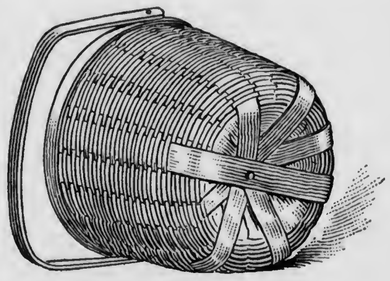

FIG. 28

FIG. 29

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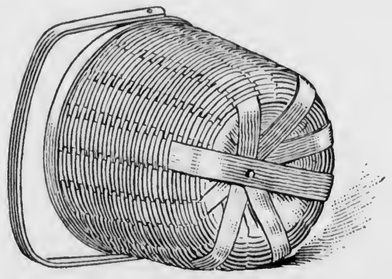

FIG. 28

FIG. 29

56. Picking Receptacles.—A picking receptacle frequently used is a wickerwork basket of the type shown in Fig. 27. Several styles similar to that pictured are on the market and can be purchased from dealers in citrus growers' supplies. Some baskets are made so that they can be carried by means of a strap across the shoulder; others are provided with a bale. The sides and bottoms of the baskets are usually padded with cloth of some kind. This protects the fruit to a certain extent from injury. When removing the fruit from the basket it should be lifted out with the hands, on account of the bruising that inevitably results if it is poured from the basket.

FIG. 30

In Fig. 28 is shown a type of basket used by L. B. Knox in his grove near Ormond, Florida. It is a half-bushel splint basket with a bale attached. An advantage of this basket is that it can be hung on the side of the ladder while being filled. In Fig. 29 is shown a view of Mr. Knox's grove at picking time. The baskets attached to the ladders can be plainly seen. When hauling the fruit to the packing house, Mr. Knox places the baskets in the wagons without emptying them, thus avoiding the extra handling of the fruit and avoiding injuries to the fruit caused by pouring them from one receptacle into another.

Growers in Florida are beginning to use the California type of picking bags to some extent. One of these bags is shown in Fig. 30. There is no bottom in the bag, but it is held

closed by fastening a ring to the hook as shown in the illustration. If it is desired to decrease the capacity of the bag, the other rings on the chain are fastened to the hook. The part of the bag that rests against the body is padded for the purpose of preventing the fruit from being bruised. The bag is carried over the shoulder, as shown in Fig. 31, and it is emptied by unhooking the chain, which allows the fruit to pass out at the bottom. This does away with the necessity of taking the fruit out with the hands. When emptying a bag the end from which the fruit passes out should rest on the bottom of the box and the bag be pulled carefully away from the fruit. If the fruit is allowed to fall into the box it is sure to be bruised.

FIG. 31

57. Field Boxes.—In Fig. 32 are shown two styles of field boxes used in Florida. The fruit from the picking bag or basket is placed in these boxes in the field, unless the picking receptacle with the fruit in it is hauled to the packing house. The field boxes are usually well made and often are reinforced with bands of sheet iron. They are designed to be piled one above the other without bruising the fruit.

58. Ladders.—Much of the fruit can be picked from the ground, but ladders are necessary for picking the fruit on the higher branches. The regular four-legged step ladder is used in some groves; other growers prefer a three-legged step ladder. For picking the fruit from the outside branches of high trees a light, strong ladder that can be leaned against the tree is used. The breadth at the base should be sufficient to prevent its tipping when laid against the tree. Ladders with a pointed end are sometimes used for getting the fruit from the inside of tall trees. When using one of these ladders the point is placed in a crotch of limbs.

59. Clippers.—The fruit is removed from the tree by means of clippers. In Fig. 33 is shown the method of holding the fruit when removing it from the tree. The fruit should be removed with only a small portion of the stem adhering to it, for a long stem left on an orange or a grapefruit will be sure to injure much of the fruit with which it comes in contact. The clippers used should have rounded points. Sharp points are likely to injure the fruit. Two modern styles of clippers are shown in Fig. 34.

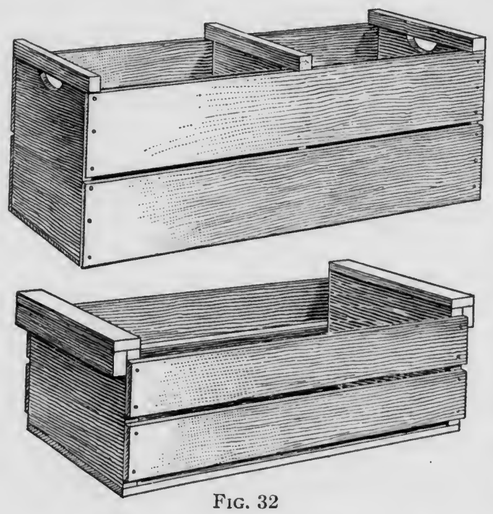

FIG. 32

60. Hauling the Fruit.—Care to prevent jarring should be exercised when hauling the fruit from the grove to the packing house. Although many growers haul their fruit from the grove to the packing house in wagons without springs, many enterprising growers use spring wagons for this purpose. In Fig. 35 is shown the Belknap orchard wagon. This wagon can be purchased with tongue or shafts as desired. There are several advantages in the use of this wagon; it has springs, which prevent much jarring of the fruit; it has a low

FIG. 33

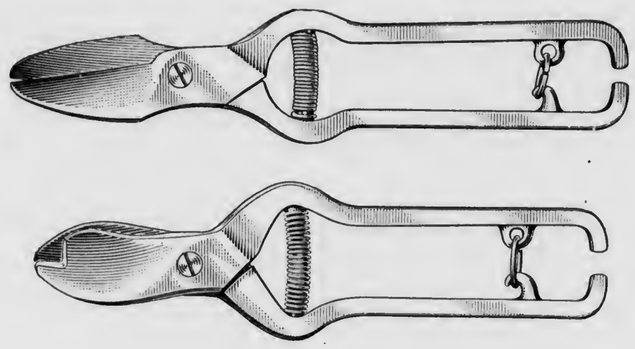

FIG. 34

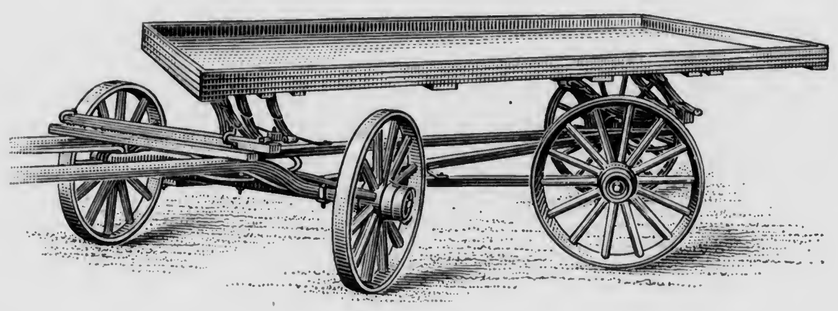

FIG. 35

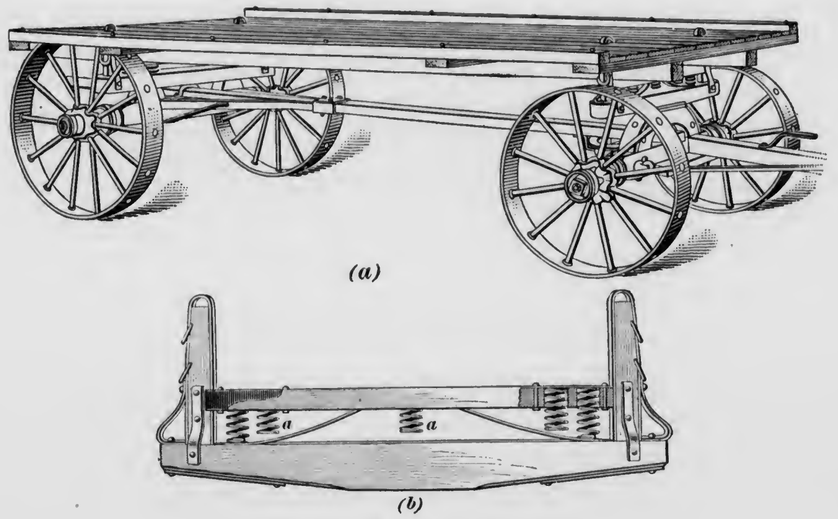

FIG. 36

bed, which does away with much raising of the boxes when loading the fruit; it has wide-tired wheels, which prevent it from cutting deeply into the soil; the gearing of the wagon is constructed with three reaches and with turning circles on each axle, thus enabling the wagon to be turned in a small space.

Another type of orchard wagon, known as the Electric Wheel wagon, is shown in Fig. 36 (*a*). This wagon is supplied with bolster springs of the type shown in (*b*). The springs *a* form a part of the bolster of the wagon.

The beds on the wagons used in groves should be of a size to hold a definite number of field boxes. Usually the manufacturers make beds of different widths and lengths; it will pay a grower to choose a bed that will accommodate a definite number of field boxes of the size that are used in his groves. In case the bed furnished by the manufacturer is not the size required one can be built to meet the requirements.

PACKING THE FRUIT

61. Packing Houses.—The fruit after it leaves the grove is taken to a packing house where it is graded, sorted, washed if necessary, wrapped in paper, and packed in boxes ready for shipment. These packing houses range from small sheds with meager equipment to large factory-like buildings equipped with all modern appliances for handling the fruit. Manufacturers can supply equipment to handle any quantity of fruit. Equipment can be had that is suitable for the grower who desires to pack his own fruit as well as for large packing houses.

Advertisements in the leading farm papers in the citrus sections will put the purchaser in touch with firms who handle packing-house equipment. When purchasing equipment, it should be remembered that the fruit must be handled in a manner to prevent bruises and that it must be handled economically and rapidly. Before purchasing packing-house equipment, it is well to visit the best packing houses in the state, learn their methods, and study the good and the bad features of their equipment.

In modern packing houses the fruit is handled largely by machinery. It is carried from one machine to another on a canvas belt, or if it is necessary to raise it from one floor to another, endless belt elevators may be used; the fruit passes from a higher to a lower level by gravity but it is not allowed to fall very far on account of the ease with which it is bruised. Among the machines in packing houses are washers in which the fruit is washed and brushed, weighing machines that record automatically the quantity of fruit that passes through the house, sizers that sort the fruit into different sizes, and box presses that hold the covers in place on the boxes while they are being nailed shut. The grading, wrapping, and packing is done by hand.

62. Washing the Fruit.—Much of the fruit when it arrives at the packing house is dirty or covered with fungous or insect growths that can be removed. The fruit is washed and brushed to improve its appearance and remove these growths. Machines are on the market that do this work automatically; the fruit is dumped into a tank of water and is carried over or past brushes that rub the surface of each fruit. Some of these machines handle the fruit more roughly than others, and in selecting a machine this matter should receive attention.

63. Scraping the Fruit.—Some of the scale insects that adhere to the fruit can easily be removed by scraping the rind with a dull knife. Some packers, when the fruit does not require washing, hire women or girls to do this work, and usually pay them a certain amount for each box. The removal of the scales very much improves the appearance of the fruit.

64. Grading the Fruit.—The fruit is graded carefully before it is sized for packing. Where the rust mite is prevalent the fruits are first separated into two classes, known as *brights* and *russets*. All those that are free from the russet markings caused by the rust mite go into the bright class, and those that show the russet markings go into the russet class. In each class the usual grades are *fancy*, *standards*, and *culls*.

Some packers have four grades, *extra fancy*, *fancy*, *standards*, and *culls*. These grades apply to both oranges and grapefruit.

The fruit that is graded in the packing house is usually carried past the graders on flat belts in such a manner that they can see each fruit as it passes to the sizing machine and separate it into the different grades. If fancy, standard, and culls are the grades, there are likely to be two horizontal belts, one for the fancies and one for the standards. A chute into which the culls are thrown is also provided. In most packing houses all of the fruit comes to the grader on one belt; all the fruit that belongs in one of the grades—fancy, for example—is permitted to pass, and the fruit that belongs in the other grade—standard, for example—is picked out and placed on the other belt. The culls are picked out and thrown into the chute intended for them. Often there are two or three graders who stand side by side, each one picking out the fruit for the different grades. There is then very little chance for the fruit to be graded improperly.

65. Weighing the Fruit.—When fruit is handled by an exchange or by some concern that packs fruit for many different growers, it is necessary that the quantity of each grower's fruit be known, and automatic machines are often installed for weighing it. The fruit is carried to the machine on a belt, and after a certain amount has collected the machine is tripped and the weight recorded automatically. The fruit then passes on a belt to the next machine.

66. Sizing the Fruit.—Oranges and grapefruit, after they have been cleaned, weighed and graded, pass to the sizing machine, where they are automatically sorted to size. In Fig. 37 is shown a sizing machine used in the Fort Myers, Florida, packing house. The fruit is carried on a belt and passes over a series of openings of different sizes; as a single fruit comes to an opening through which it will pass, it drops through into a shallow bin. All the fruit in each bin is therefore approximately the same size. The sizes of the openings through which the fruits drop are governed by the number of fruits that can be packed in the standard-sized market package.

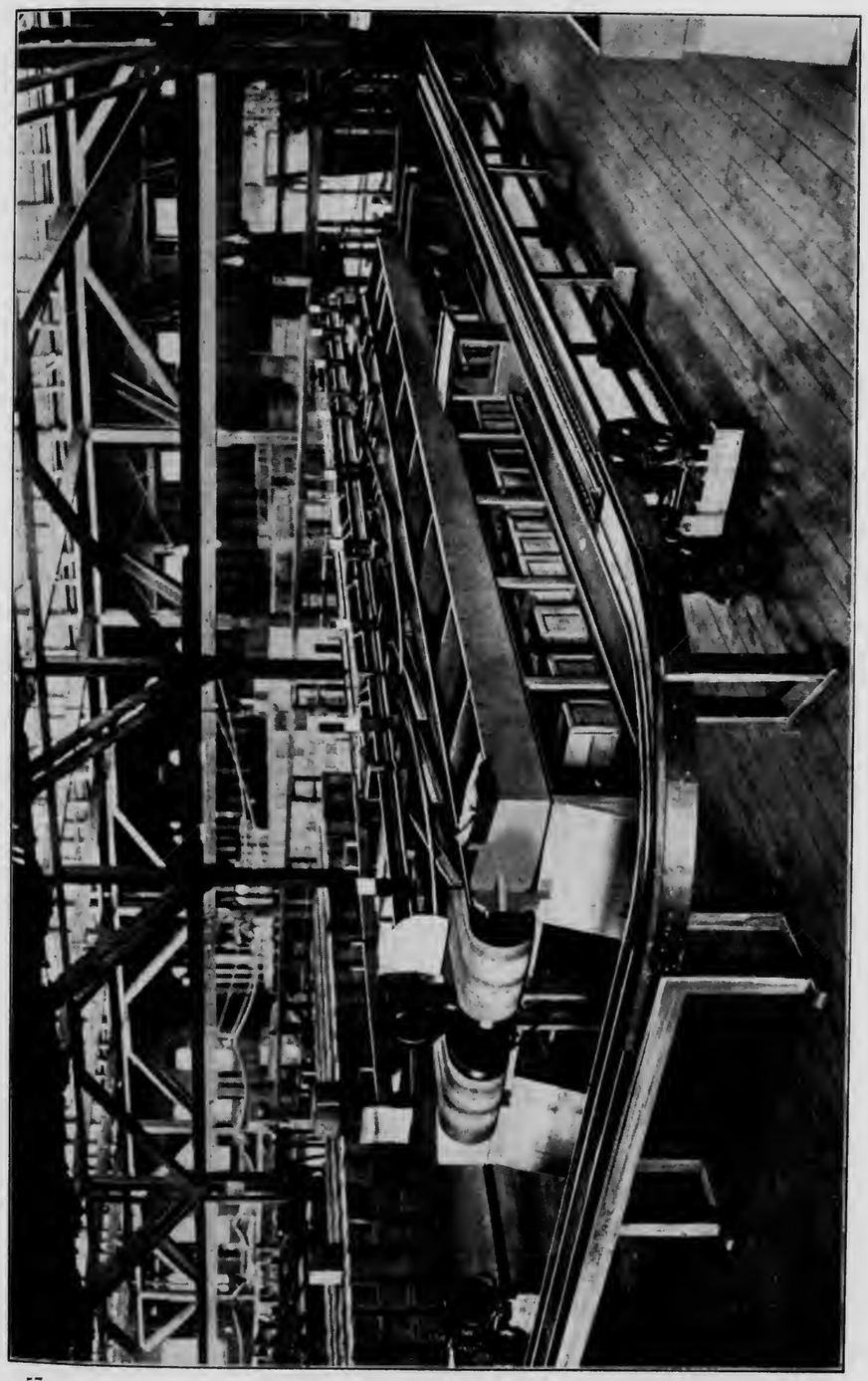

FIG. 37

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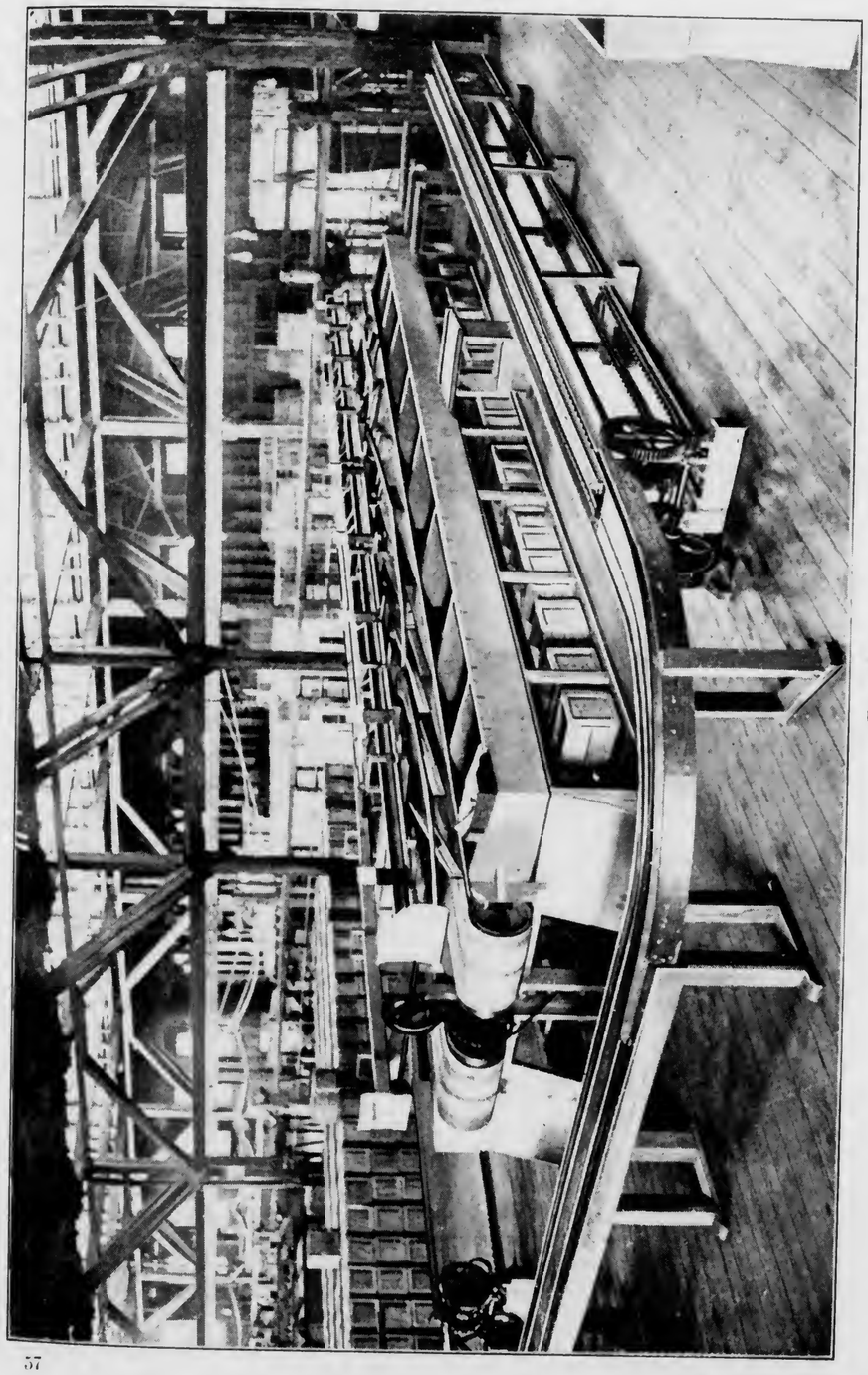

FIG. 37

67. Labeling the Fruit.—A few packers make a practice of pasting a small label to each fruit for the purpose of advertising their product. In Fig. 38 is shown a label used by B. E. Tinstman, of Fort Myers, Florida. The original labels are in color and are very attractive. Such labels become known on the market, and if the fruit is as it should be, creates a demand for the product.

FIG. 38

68. Wrapping the Fruit.—Each orange or grapefruit is wrapped in tissue paper before it is placed in the box. Packers become very dexterous in this work and very little more time is required to pack the fruit

FIG. 39

wrapped than to pack it without wrapping. A label in colors is usually printed on each paper, especially if the fruit is of

the best grades. Fruit of poor quality is sometimes wrapped in plain paper. In Fig. 39 are shown several illustrations of the labels on wrappers used on Florida fruit. The originals of

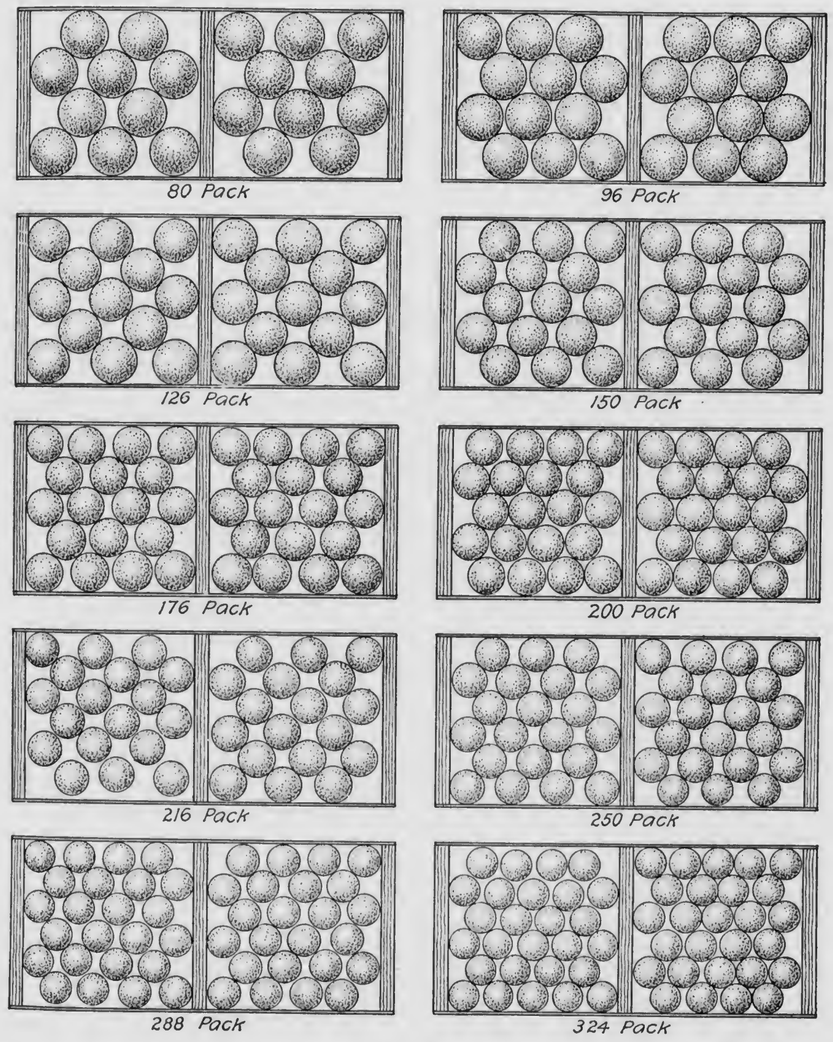

FIG. 40

these are in color, but for purpose of illustration they are reproduced here in black and white. Attractive labels become a prominent means of advertising the fruit of the different growers and packers.

69. Boxing the Fruit.—The fruit is packed in the boxes in layers by hand, each packer standing by a bin of the sizing machine. The boxes used in Florida are of uniform size, and differ somewhat from the California box. The standard box of Florida, the size of which is fixed by law, contains two compartments, each 12 in. × 12 in. × 12 in., inside measure-

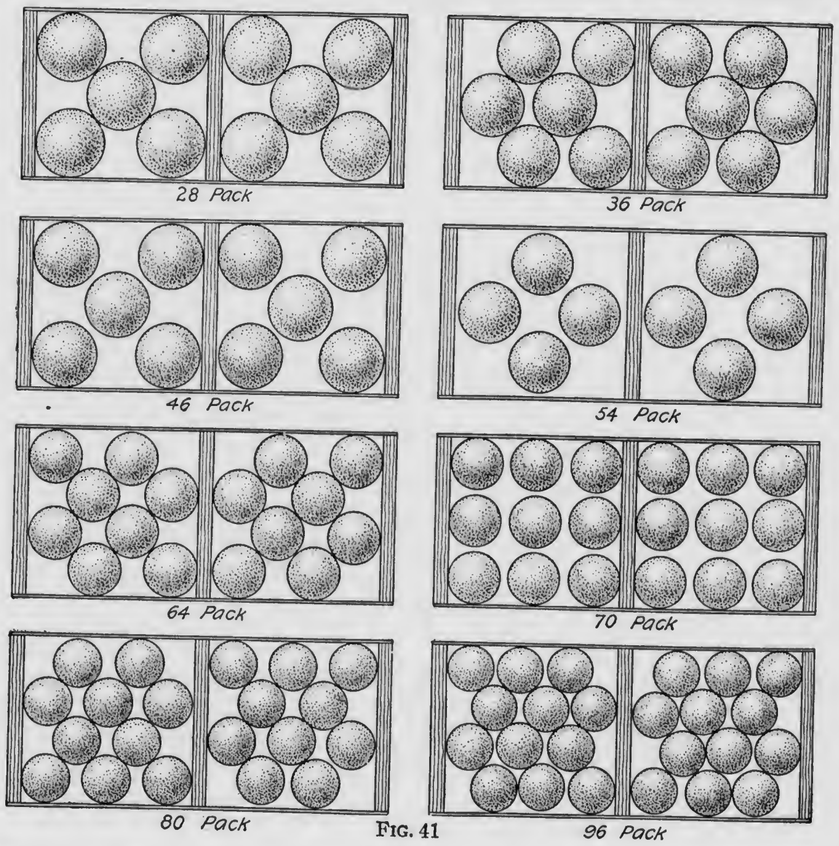

FIG. 41

ments. They are made with paneled or with plain ends as desired.

A definite number of fruits is placed in each box, the number in any box being governed, of course, by the size of the fruits. In Fig. 40 is shown in diagram the arrangement of the first layers and the number of fruits in a box for the different orange packs; in Fig. 41 the same is shown for the tangerine packs, and in Fig. 42 the same is shown for the grapefruit packs.

In arranging the second and subsequent layers the fruits are made to fit down as far as they will go into the spaces between the fruits of the previous layer. The last layer put into the box will be on the top of the box when it is opened. The fruits should fit snugly in place, but they should not be pressed down too hard when being put in place, on account

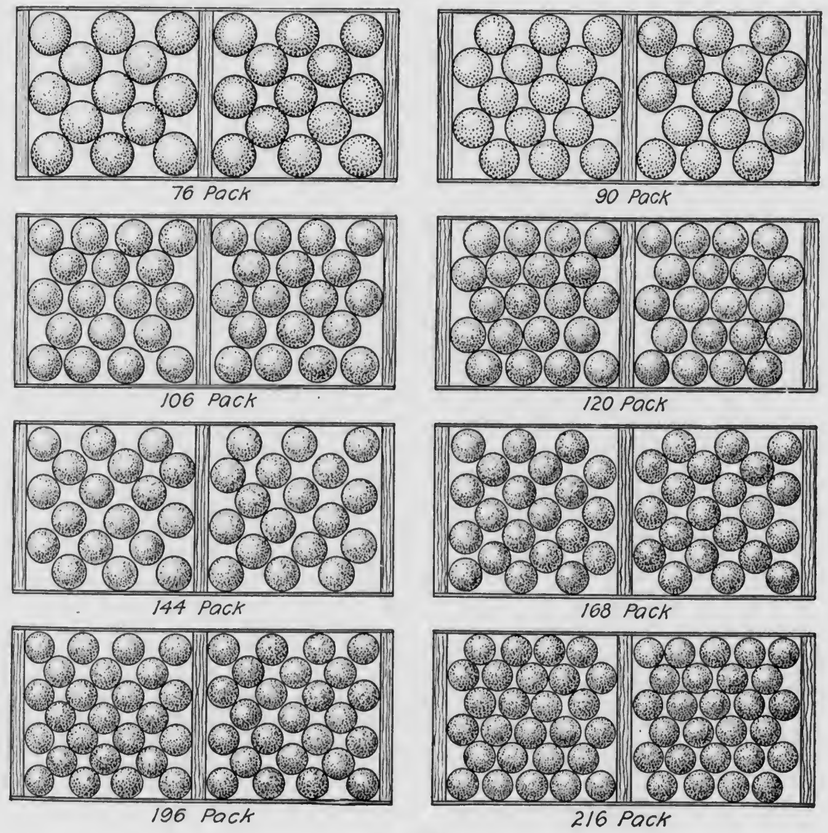

FIG. 42

of bruising. The last layer of fruit should project about $\frac{1}{2}$ inch above the level of the box. This provides for the bulge, which is described in a subsequent article. The packer, when finishing the last layer, stamps the number of fruits on the outside of the box and then sends it to the man who nails on the covers. In Fig. 43 is shown a well-packed box of oranges. Note the evenness and regularity of the pack.

Tangerines and Satsuma and King oranges are usually packed in half boxes. These are the same width and length as the standard boxes, but are only half as high. The arrangement of the layers is practically the same as for the round fruits. In Fig. 44 is shown a well-packed half box of tangerines. When shipping fruit packed in half boxes, or half straps as they are often called, two boxes are fastened together, one being placed above the other.

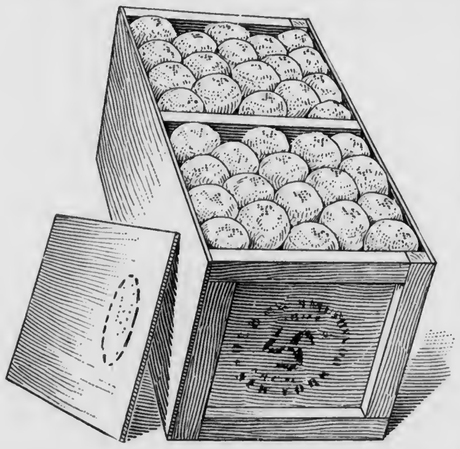

FIG. 43

Kumquats are usually packed in quart boxes such as are used for strawberries, etc. They are arranged in layers and a few leaves are placed among the fruit to give it an attractive appearance. Fig. 45 illustrates a quart basket of kumquats as displayed on the market. These quart boxes are packed for shipment in regular strawberry crates.

FIG. 44

The ends and sides of the boxes containing oranges or grapefruit usually have printed on them the name of the brand and the grower or the shipper. In a few cases, lithographed labels such as are used in California are pasted on the boxes, but printed labels are much more common. The printing is usually in colors and in many cases the designs are very attractive. In Figs. 46, 47, and 48 are shown designs from Florida boxes.

70. Covering the Boxes.—Following the packing of the boxes, the covers are nailed in place. The work of nailing

on the covers in a large packing house is done by a separate set of men. Often the boxes are carried on a flat belt from the packers to the men who nail on the covers. Use is made of a box press that holds the covers in place and presses down the ends, leaving a bulge in the center. The lids as they are held in place are nailed at both ends. The purpose of the bulge is to hold the fruit tight in the box. After the cover is

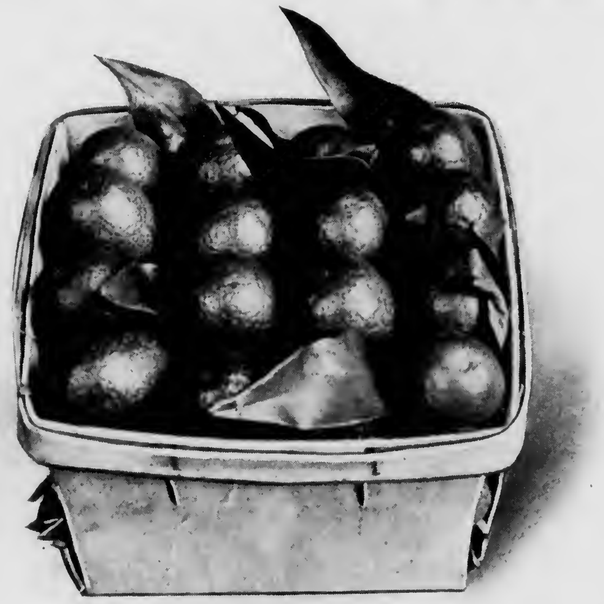

FIG. 45

nailed on straps of metal or wood are placed around the ends and the middle of the box to strengthen and protect it until it reaches its destination.

71. Loading the Fruit.—The fruit is shipped by rail or by boat. The boxes are hauled from the packing house to the car or boat in which they are to be shipped; they are placed on end with an inch or so space between them for ventilation. In a car the boxes usually stand two deep and two narrow strips of wood the width of the car are nailed to each row of boxes crosswise of the car. These strips keep the boxes from swinging back and forth with the side swing of the car when

the train is in motion, and also keep the boxes apart and thus permit ventilation. The ends of the car are loaded first and the middle portion last. The last boxes are wedged very tightly into place. A press is used to take up all possible space between the boxes lengthwise of the car. The motion back and forth lengthwise of the car while in transit will do much damage to the fruit unless this precaution is taken.

72. Selling the Fruit.—Several methods of disposing of the product are open to the citrus grower. In Florida the fruit can be sold through the Florida Citrus Exchange, which has offices at all important fruit centers; it can be shipped direct to commission merchants in distant cities or to local commission men; it can often be sold as it hangs on the trees to buyers who travel through the citrus section during the picking season; it can be consigned to the grower himself at a northern market and he can go there and dispose of the product; or it can be sold by mail to northern buyers and shipped in small lots by express. Just which selling method to adopt is an individual matter; each method has some points in its favor.

FIG. 46

The Florida Citrus Exchange is a cooperative organization that packs, ships, and sells the fruit of its members. The exchange maintains packing houses at important shipping centers and to these the members bring their fruit. All the work of washing, grading, sorting, boxing, loading, shipping, and selling the fruit is done through the management of the exchange, and hence the grower is relieved from responsibility as soon as he delivers his fruit at the packing house. The exchange has agents in large market centers who sell the fruit.

The manager keeps in touch with the agents and ships the fruit whenever and wherever it can be disposed of most profitably. Selling through the exchange has many points in its favor, especially for the small grower who cannot give much attention to market conditions.

Selling through commission merchants has good and bad features. If the firm is reliable there may be times when a shipment can be disposed of more satisfactorily than through the exchange. Again, the condition will be reversed. If selling on commission, the best advice that can be given is to deal honestly with a firm that does an honest business. There are many such firms to be found, and often a grower,

FIG. 47

especially if he has worked up a trade for a particular brand, will find selling on commission to be a profitable way for him to dispose of his fruit.

Selling the fruit on the trees sometimes proves a very desirable way to dispose of the product. If the grower does not have equipment to pick the fruit to the best advantage, this is perhaps the best method he can follow. However, it must be remembered that the buyers are experts on estimating the approximate quantity of fruit in a grove and that they are well posted on current prices, and for these reasons it will pay a grower to get estimates from several such buyers, and, further, to acquaint himself with prices and estimate carefully the quantity of fruit in his grove. By following this plan he is likely to get more for his fruit than were he to accept the first offer made for it.

Consigning the fruit in a grower's own name to a distant market and the grower going to this market and disposing of the fruit to dealers has at times proved a profitable way of selling the product of a grove.

Selling citrus fruit by mail direct to the consumer is practiced by a few growers. They will sell full boxes of either oranges or grapefruit, or mixed boxes that are half filled with oranges and half with grapefruit. Usually they make a practice of furnishing only the best grade of fruit, and select it carefully for size and color. The packages are attractively packed. Some growers pack Spanish moss on the top and place a few kumquats among the moss to give the box a pleasing appearance when it is opened. Shipments to mail-order trade are, as a rule, made by express, although some men take advantage of boat rates from Florida to New York or other Northern ports, and then have the fruit shipped by express from the

FIG. 48

northern port to its destination. This usually reduces the transportation charges considerably. Two boxes can usually be shipped at the same cost as one box, and for this reason mail orders are generally sent out in consignments of two boxes or multiples of this number.

73. The culls from packing houses are disposed of locally. Often many of the fruits are sound but are so badly scarred that they cannot be placed even in the standard grade. If used at once, however, they are really as good as sound fruit. Such fruit often brings a fair return to the grower in a local market.

Decayed fruit meets with no demand for human consumption but, unless too badly spoiled, it may be useful for hogs.

CITRUS FRUITS IN GULF-COAST STATES

(PART 3)

INSECTS AND DISEASES INJURIOUS TO CITRUS FRUITS

INSECTS INJURIOUS TO CITRUS FRUITS

WHITE FLIES

1. The most annoying pests in the citrus groves of Florida are the white flies, which are small, scale-like insects. These insects injure the plants in two ways: By sucking the sap from the leaves and by depositing a substance known as honeydew. The loss of sap, if the flies are numerous enough, will materially reduce the yield and the size of fruit, and may even result in a stunting of the growth of the tree itself. The honeydew deposited provides a suitable medium for the growth of a black fungus known as sooty mold, which is even more injurious than the flies themselves. This sooty mold spreads rapidly, and trees often become so black that a badly infested grove can be recognized from a considerable distance.

It can readily be seen that a fungus that covers the trees so thoroughly as does the sooty mold will interfere seriously with the proper functions of the leaves by partly shutting out the sunlight and by preventing the proper exchange of gases. Moreover, the fruit that is coated with sooty mold must be

washed before it can be marketed, which adds to the cost of marketing; also, in the washing and drying processes, the rind is apt to be injured, and the wounds become infected with the spores of various molds that cause the decay of the fruit before it reaches the consumer.

There are three species of white flies that do damage to citrus fruit trees in Florida, the *common citrus white fly*, the *cloudy-winged white fly*, and the *woolly white fly*.

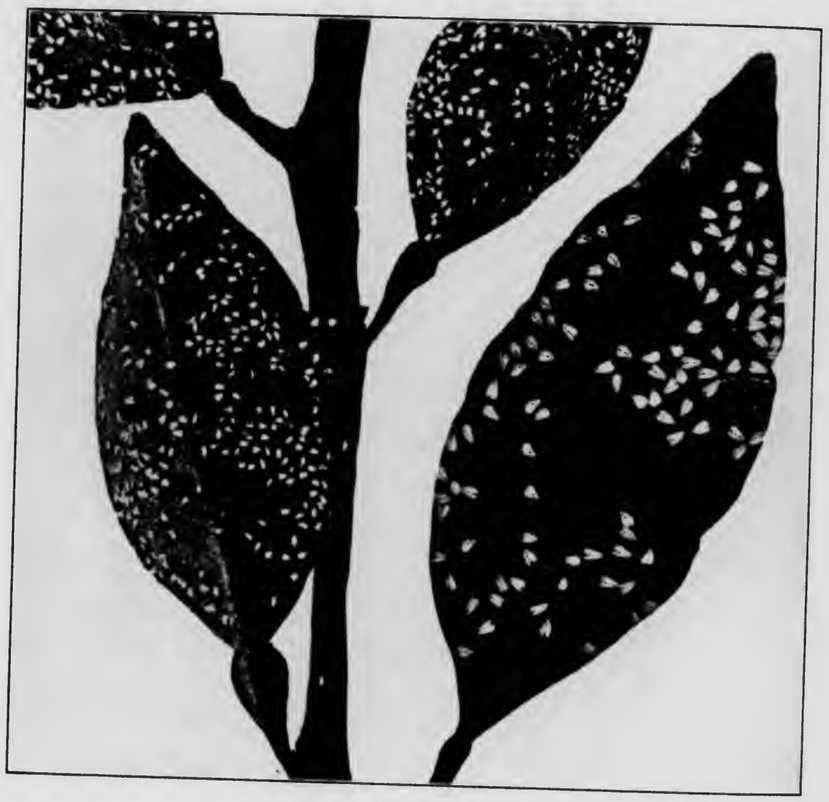

FIG. 1

2. Common Citrus White Fly.—By far the most abundant of the three species of white flies is the common citrus white fly. This insect is present in most of the principal citrus fruit-growing sections of Florida, and is abundant on citrus and other plants from South Carolina to Texas. There are, however,

isolated communities and groves in Florida, especially on the lower part of the east coast, into which it has not yet found its way.

The adult citrus white fly is a small, white, four-winged insect, measuring less than $\frac{1}{8}$ inch across the outstretched wings. In their early stages the male and female are much alike, which is the case with practically all insects. When the mature stage is reached, however, the male is slightly smaller than the female. The adult insects, both male and female, live only a short time. The male dies immediately after fertilizing the female; the female lives a few days longer, until eggs have been deposited. Since the male dies so soon after maturing it does not cause much damage to the trees. It is the female which the grower sees and fights. This is true of practically all insects.

FIG. 2

3. The citrus white fly avoids the direct rays of the sun and during the day is found on the under side of the youngest and most tender leaves, from which it sucks the sap and often causes them to curl and fail to reach their proper size. At dusk and again in the early morning the female insect flies about in search of plants suitable for food and for the deposition of eggs. It ordinarily does not fly far, but may drift with the wind for a distance of 2 or 3 miles. After the female finds a suitable food plant, she lays her eggs on it. These are pale yellow, oval-cylindrical bodies about $\frac{1}{125}$ of an inch long. In Fig. 1 the common citrus white flies are shown on the orange leaf. The eggs are shown much enlarged in Fig. 2. They are attached to the leaf by a stem, which can be plainly seen in

the illustration. Each female lays 250 eggs or less, and these hatch out, in from 3 to 20 days, into small, oval, flat, six-legged insects that crawl about for a few hours only.

FIG. 3

The larvas in their first stage are called *crawlers*. They soon find a suitable spot for feeding, where they insert their sucking mouth parts and do not move again until they become adults. In Fig. 3 is shown the first larval stage of the citrus white fly much enlarged. At the end of from 1 to 3 weeks, according to temperature, the larva casts its skin, or molts, and passes into the second larval stage. It has now lost its legs and antennæ, or feelers, and has become exceedingly flat and oval in outline and is pressed very closely against the leaf, from which it sucks the sap. In Fig. 4 the larvas of the citrus white fly are shown in twice their natural size on an orange leaf. The larva is covered with a rather tough skin, is pale yellowish

FIG. 4

green in color, and is so nearly the color of the leaf that it is hard to detect. By bending the upper surface of the leaf sharply, the insects are made to stand out more prominently on the leaf and they can readily be seen.

The insects remain in the second larval stage for a week or less in warm weather, then molt again and pass into the third larval stage. In Fig. 5 the citrus white fly, very much enlarged, is shown in the third larval stage. In this stage it differs from the second larval stage only in size. After another molt the insect passes into the pupal stage and becomes distinctly thicker and larger in diameter. Soon after it passes into the pupal stage there appears in the middle of the insect a bright-red spot. Later the eyes, wings, and other organs of the adult form and begin to show through the semitransparent skin. After about 10 days in summer and 30 days in the winter the adult pushes its way out from the pupa case through a T-shaped incision, the snow-white case remaining on the leaf. An empty pupa case with its characteristic incision is shown in Fig. 6.

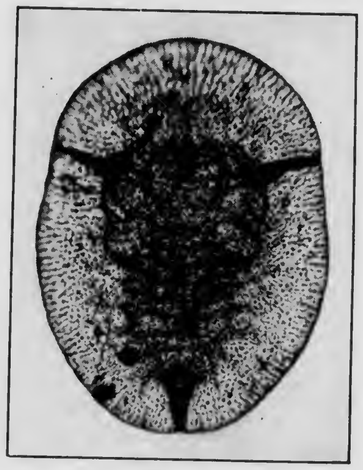

FIG. 5

4. The citrus white fly completes its life history in a period of from 6 to 8 weeks in summer. There are at least three broods each year. The first brood matures in March or early April. The second brood matures in June and July, extending into August in the northern part of the Florida citrus belt. The third brood of adults matures in September, and these adults produce a brood that spend the winter as larvas on the leaves. It is this brood of larvas that gives rise to the first brood of adults in the spring. The exact dates at which the various broods make their appearance will vary for different years and for different latitudes, being earliest in the southern

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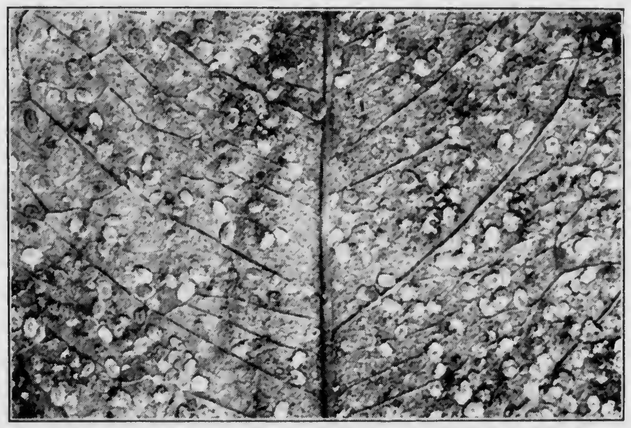

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part of Florida and latest in the Northern part of Florida along the gulf coast. In Florida there will sometimes be a fourth incomplete brood in January if the weather is warm. Toward the end of summer the broods begin to overlap, belated members of the second brood flying with precocious members of the third, so that during the latter part of the season there are some adults to be found on the trees at all times.

5. In the United States there are not many insect enemies of the common citrus white fly to hold it in check. Ladybird beetles eat a few, as do also the young of the lace-winged fly

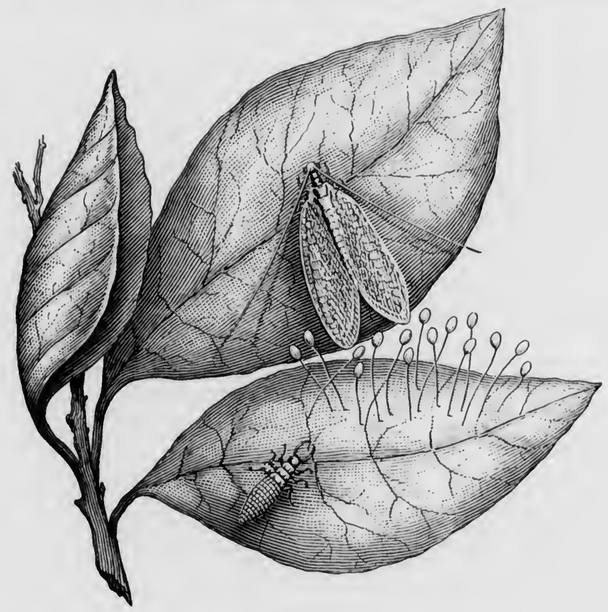
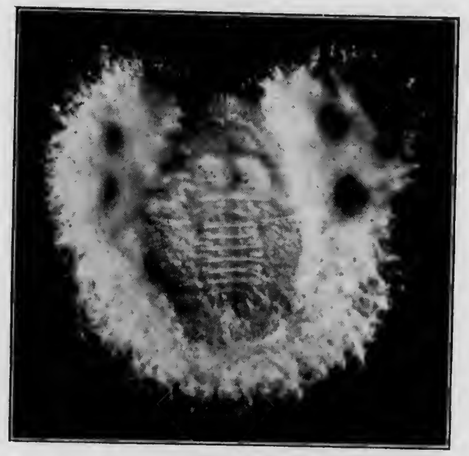


FIG. 7

and of a species of thrips. Fig. 7 shows the adult lace-winged fly, the larva, and eggs. The eggs of this fly are borne on stems attached to the leaf, as shown in the illustration.

Fungous enemies are very efficient in holding the citrus white flies in check. During the hot and rainy season in Florida, which usually begins in June and lasts into September, fungi flourish. Many kinds of fungi grow on insects and kill them. Four different kinds of fungi live as parasites on the larvas of the citrus white fly. One of these, called the *red aschersonia*,

forms on the larva a bright-red pustule, or pycnidium, which is a spore-bearing receptacle. The red aschersonia fungus much enlarged is shown in Fig. 8 growing on a larva of the citrus white fly. This fungus is very conspicuous on the surface of green leaves, as shown in Fig. 9. Another fungus known as the brown fungus, produces a similar pustule of a brown color. This fungus sends out microscopic threads, which, if not checked by dry weather, will extend to all parts of the leaf and kill all white-fly larvas present. These threads often extend around to the upper surface of the leaf, where they form brown spores that, to the unaided eye look like dust or coal soot on the leaves. Fig. 10 shows a leaf covered with the brown fungus. This fungus thrives best from late August to late October or November, whereas the red aschersonia



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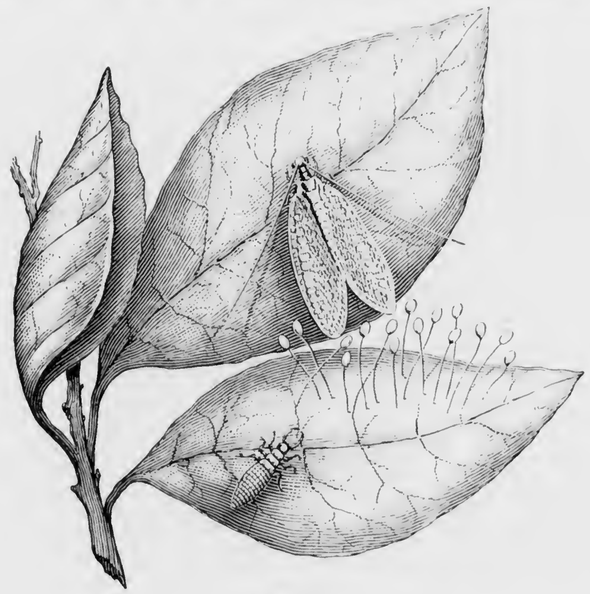

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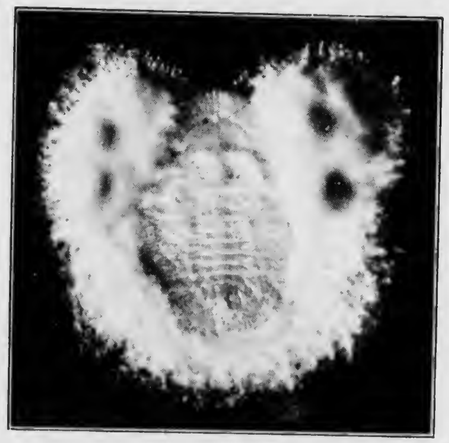

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fly is known as the white-fringed fungus; it does not form conspicuous pustules but causes the larva to turn brown and sometimes, when fully developed on the victim, shows a delicate white fringe about the insect. The white-fringed fungus attacks not only the larvas of the white fly but also attacks the eggs and the adults. Growth continues at all seasons of the year, but it is best in September and October.

So efficient are these fungi in controlling the white flies that even when not aided in their spread by the owner of the grove, they can usually be depended on to so reduce the numbers of insects as to allow the grove to produce, every third year, fruit so free from sooty mold that it does not need to be washed. Unfortunately, however, the growth and spread of these parasitic fungi is checked or entirely stopped during the dry or cooler weather of winter and spring.

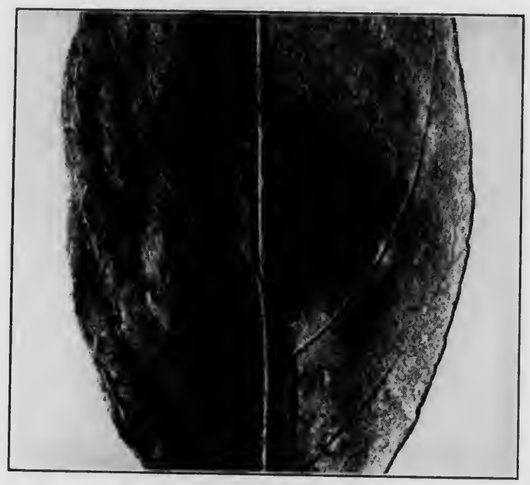


FIG. 10

6. There are three methods chiefly employed in fighting the white fly; (1) fumigation, (2) spraying with contact insecticides, and (3) spraying with the spores of the parasitic fungi.

7. The most thorough method of ridding a tree of white flies, or any other insect pest, is by fumigation. Fumigation is not popular with the growers of Florida and the gulf coast. The reasons for this are that fumigation can be employed for only a short time in winter, it is expensive, and it does not produce lasting results unless every grove and food plant in the community is fumigated at the same time, since a fumigated grove is quickly reinfested from unfumigated surrounding ones, if such exist. Fumigation is used also to rid nursery

stock of white flies and scale insects. The stock to be fumigated is placed in a tight box such as shown in Fig. 11. In an earthenware vessel is placed 3 fluid ounces of water for each 150 cubic feet of space the box contains. Into the water is poured 1 fluid ounce of concentrated sulphuric acid. The vessel is then placed in the box and 1 ounce of potassium cyanide or $\frac{2}{3}$ ounce of sodium cyanide in a paper bag is dropped into the liquid, and the box is quickly closed and left for 24 hours. Both the potassium cyanide and its gas are extremely poisonous and must be handled with great caution, but it can be safely used by a careful person.

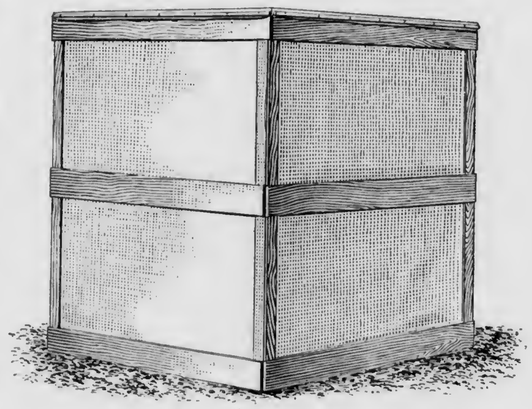


FIG. 11

8. Miscible oil sprays are most used to control the citrus white flies. These sprays are emulsions of petroleum oils and soap. One recommended by the United States Bureau of Entomology is the following: Whale-oil soap, 8 pounds or 1 gallon; junior red engine or other paraffin oil, 2 gallons; water, 1 gallon. Dissolve the soap in 1 gallon of hot water. Pour the oil slowly into the soap solution and stir constantly and vigorously so that at no time is there any free oil on the surface. When ready to spray, dilute the mixture to make 200 gallons of spray. Care must be taken to choose oil that does not contain sulphuric acid, rosin oil, or carbolic acid. There are several similar proprietary brands of such sprays on the market which are much used by growers. Kerosene emulsion, whale-oil-soap solution alone, or any laundry-soap solution does good work; all are used on a small scale on dooryard trees when miscible oil is not available. Such sprays as these should preferably be applied by a power sprayer. A sprayer with a good agitator is necessary, so that the oil will not separate from the soap solution. A pressure of

150 pounds to 175 pounds should be maintained in the pump so that the spray can be put on the tree in as fine a mist as possible.

9. There is a time in the life of most insects when they are most vulnerable, and by taking advantage of this vulnerable period a grower can combat them most effectively and with the least expense and trouble. This period is, in the case of the white flies, just after they have hatched. They are not only most easily killed by the oil sprays at this stage but, also, the grower secures another advantage in that he saves to the plant the sap the insects would withdraw and prevents the annoyance of the sooty mold that would be formed during the growth of the larvas.

The older larvas are more resistant to the sprays and the eggs still more so, on account of their thick covering; the adults, by taking flight the moment the spray hits the tree, largely escape. Spraying, therefore, should be done about 10 days or 2 weeks after most of the adult insects have disappeared. This will usually be sometime in October and again in April or early in May, depending on the season and locality. During the interval of 10 days the eggs will have hatched and the larvas of the spring brood will be in the right stage to spray. The June and July brood is not so well defined. There is more or less overlapping of broods in the summer, so that there are always some adults about. For this reason, but more on account of the summer rains, a spraying in July, at a similar period in the life history of the summer brood, is less satisfactory. The October spraying is especially important, because if the trees are freed of white flies at this time, they will remain free all winter. Moreover, the oil loosens up the sooty mold so that the rains may wash it off, leaving the leaves clean for the winter, and thus reducing the labor of washing fruit. Usually, these two applications of spray will keep the trees reasonably free of the pest. If not, a third application may be made during the winter. It is, however, not advisable to spray the trees more than two or three times in a season with these heavy oils. Frequent applications will cause the leaves and fruit to become deeply coated, thus interfering with the exchange of gases between the leaves and the air and stunting the growth of the fruit and retarding its ripening. Indeed, if the fall spraying is thoroughly done, the spring spraying may often be omitted.

10. The various fungi do excellent work in checking the white flies during the rainy season. But, since these fungi grow little during the winter and spring and their spores are blown and washed out of the trees, the white flies are usually comparatively free from parasitic fungi at the beginning of the rainy season in June. For this reason it is best to reintroduce or spread the parasitic fungi throughout the grove at the beginning of the summer rainy season. The parasitic fungi should be collected in the fall, from October to December, and either preserved on the leaves or grown on artificial media. The usual practice is to preserve the fungi on the leaves, as this involves the least work. Leaves containing larvas of the white fly infested with parasitic fungi are usually called *fungous material*. Fungous material may be kept over winter in cold storage or it may be carefully dried in a place where there is free circulation of air but no sunlight and kept in an airy box through the winter and spring. If the fungous material is to be kept in cold storage the leaves are dried for a day or so and then placed in a tight tin box and kept as near the freezing temperature as possible. When taken out in June the spores will be bright in color and will be found to have retained their vitality. If fungous material is very scarce the supply may be indefinitely increased by growing the fungi on the sweet potato. Large sweet potatoes are cut up into slices a half inch square in cross-section and 3 or 4 inches long. These are placed in wide-mouthed stoppered bottles and are then boiled for a half hour on each of three consecutive days. After the potato has cooled there is introduced a drop of water containing spores of the fungus and the mouth of the bottle is quickly plugged with a wad of cotton to keep out bacteria. In a month or more the fungus will have grown sufficiently to show some color and is ready for use. It can, however, be kept for several months in a cool place. When it is to be used it is filtered

through cheesecloth and sprayed into water. In saving fungous material of the brown fungus care should be taken to see that spores are present. Generally a supply of the fungus can be found in some favorable situation where it has survived unfavorable weather. Several men in Florida make it their business to keep this fungus on hand to sell to growers.

11. The fungi may be introduced into the trees by pinning fungous material to leaves infested with larvas of the white fly. A better method, however, is to wash off the spores in water and spray this into the trees. About forty pustules of the fungus are used to a pint of water. It is important not to use a pump, tank, or hose that was used for Bordeaux mixture, lime-sulphur, or any other fungicide. A pump should be kept for this purpose alone, and the tank should be of galvanized iron rather than of copper. It is preferable to spray every tree thoroughly in order to give the fungus an early start, but as the fungus is usually too scarce to permit this, the common practice is to spray only a part of each tree and allow the fungus to spread by natural means to the other parts. This natural spread is brought about by the rain washing the spores on to leaves underneath and by the spores being carried on the feet of insects, including the adult white flies themselves. Good results have attended the introduction of the fungus during a rainy season in April, but as a general thing better results will be obtained at the beginning of the rainy season in June.

12. In any treatment for insects it is important to keep in mind all their food plants. The white fly feeds on a number of plants, and if any of these grow in the vicinity of a grove they must be looked after as carefully as the citrus trees. By far the most important of the food plants of the white fly other than the citrus tree is the chinaberry tree, including the variety called the umbrella tree. Both are common dooryard trees throughout the gulf citrus region. The insect eats the leaves of these trees in preference to citrus. As a result, they become thoroughly infested during the summer. The leaves of these trees are deciduous and as they become hard and dry in the fall, the adults of the fall brood desert them and swarm to

the citrus trees, literally millions from each tree. If these trees could be thoroughly sprayed during the summer they would act as traps and save the citrus trees, but this seems to be impractical. The trees grow to be very large and very dense, and being scattered along the streets and about the houses of people who own no groves, they are commonly neglected. The only practical method of dealing with them seems to be to destroy them and to prohibit their being planted in citrus districts, and this is commonly done. Other host plants which can be, and, if planted at all, should be, sprayed are japonica, privet, cherry laurel, wild olive, jasmine, prickly ash, ash, wild persimmon, and over thirty others that are less common or less severely infested. These other host plants constitute a danger, too, in that they are liable to be shipped into non-infested territory and thus spread the white fly.

13. The Cloudy-Winged White Fly.—In the southern part of Florida the cloudy-winged white fly is very common. It was formerly spread over the entire state and as far west as Louisiana at least, but since the cloudy-winged white fly occurs only on citrus fruit trees, it was exterminated in the northern part of its range by the freeze of 1895, which defoliated all of the trees in that region and froze most of them to the ground.

FIG. 12

In Fig. 12 is shown the cloudy-winged white fly magnified about twenty-five times. With the unaided eye the adult of this species cannot be distinguished from the common citrus white fly, but with the aid of good lens there can be made out on each front wing a dark clouded area, which has given this insect its name. The eggs are readily distinguished from those of the common white fly by their color, which is dark brown except for a short time immediately after they are laid, when they are gray. In Fig. 13 the eggs of the cloudy winged white fly are shown much

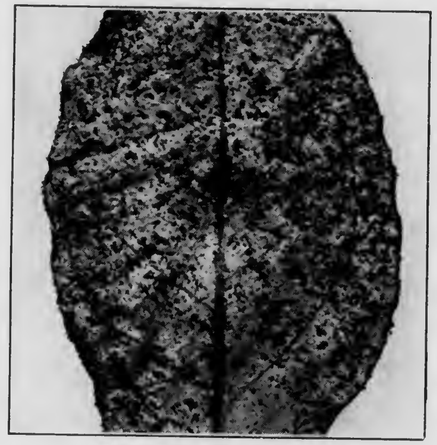
enlarged. The ridges are very noticeable. Those eggs with holes in have hatched. Under a microscope they are seen to be not smooth like those of the common citrus species, but reticulated or covered with a fine network of raised ridges. Fig. 14 shows eggs of the cloudy white fly natural size deposited on an orange leaf.

The larva is very similar to that of the common citrus white fly but the pupa is larger and thinner, and the pupa case collapses completely after the emergency of the adult. Not only does the cloudy-winged white fly look much like the common citrus white fly in general appearance, but the life history is very similar, except that the broods are from 2 weeks to a month later and there is no winter brood. The natural enemies also are about the same, except that there is in addition to the parasites of the common citrus white fly, a yellow fungus. This fungus is very similar to the red fungus except for the deep yellow color. The white-fringed fungus also attacks this species of white fly more severely than it does the common citrus white fly.

FIG. 13

14. Control is the same in principle as that practiced for the common white fly. At the beginning of the rainy season in June parasitic fungus is spread on the trees, and in addition, if necessary, two sprayings with some one of the heavy oils are given. Since the larvas of the cloudy-winged white fly hatch about 2 weeks later than those of the common white fly, these sprayings may be done later, but the rule for spraying is the same; that is, it should be done 2 weeks after the bulk of the adults have disappeared. This will be November for the fall brood and late April or in May for the spring brood.

Over a large part of its area of distribution, the cloudy-winged white fly occurs mixed with the common citrus white fly. As was said before, the eggs of the cloudy-winged white fly hatch about 2 weeks after the eggs of the common white fly. It would seem that by delaying the spray application for the common white fly 2 weeks, one spray application could be made to suffice for both the common white fly and the cloudy-winged white fly. Such spraying, however, while economical, is not thorough in its results and should not be resorted to, especially in the spring when the growth of the insects is very rapid. As soon as the eggs of the common white fly hatch the larvas develop rapidly and by the time the eggs of the cloudy-winged white fly have hatched the larvas of the common white fly are about ready to pass into the pupal stage. In the pupal stage the insects are so resistant that many of them will not be killed by the oil. It also happens that in mixed infestations the cloudy-winged white fly does less damage than the common citrus white fly, so it is imperative to control, at the most vulnerable period in its life history, the pest that does the most damage. If, however, it is desirable to economize in the application of sprays and make one spray answer for both species, the best time to spray is in the fall. Growth of the insects is not so rapid in the fall on account of the weather being cooler. When the spray is applied after the cloudy-winged white fly has hatched, the larvas of the common citrus white flies will not be so fully developed as to be wholly resistant to the oil sprays. In either case, spring or fall, it is far better, if lasting results are to be obtained, that the spray be applied when each insect can be combated most successfully.



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The larva is very similar to that of the common citrus white fly but the pupa is larger and thinner, and the pupa case collapses completely after the emergency of the adult. Not only does the cloudy-winged white fly look much like the common citrus white fly in general appearance, but the life history is very similar, except that the broods are from 2 weeks to a month later and there is no winter brood. The natural enemies also are about the same, except that there is in addition to the parasites of the common citrus white fly, a yellow fungus. This fungus is very similar to the red fungus except for the deep yellow color. The white-fringed fungus also attacks this species of white fly more severely than it does the common citrus white fly.

FIG. 13

14. Control is the same in principle as that practiced for the common white fly. At the beginning of the rainy season in June parasitic fungus is spread on the trees, and in addition, if necessary, two sprayings with some one of the heavy oils are given. Since the larvas of the cloudy-winged white fly hatch about 2 weeks later than those of the common white fly, these sprayings may be done later, but the rule for spraying is the same; that is, it should be done 2 weeks after the bulk of the adults have disappeared. This will be November for the fall brood and late April or in May for the spring brood.

Over a large part of its area of distribution, the cloudy-winged white fly occurs mixed with the common citrus white fly. As was said before, the eggs of the cloudy-winged white fly hatch about 2 weeks after the eggs of the common white fly. It would seem that by delaying the spray application for the common white fly 2 weeks, one spray application could be made to suffice for both the common white fly and the cloudy-winged white fly. Such spraying, however, while economical, is not thorough in its results and should not be resorted to, especially in the spring when the growth of the insects is very rapid. As soon as the eggs of the common white fly hatch the larvas develop rapidly and by the time the eggs of the cloudy-winged white fly have hatched the larvas of the common white fly are about ready to pass into the pupal stage. In the pupal stage the insects are so resistant that many of them will not be killed by the oil. It also happens that in mixed infestations the cloudy-winged white fly does less damage than the common citrus white fly, so it is imperative to control, at the most vulnerable period in its life history, the pest that does the most damage. If, however, it is desirable to economize in the application of sprays and make one spray answer for both species, the best time to spray is in the fall. Growth of the insects is not so rapid in the fall on account of the weather being cooler. When the spray is applied after the cloudy-winged white fly has hatched, the larvas of the common citrus white flies will not be so fully developed as to be wholly resistant to the oil sprays. In either case, spring or fall, it is far better, if lasting results are to be obtained, that the spray be applied when each insect can be combated most successfully.

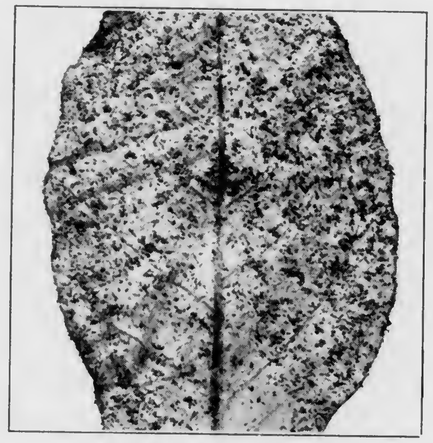

FIG. 14

The cloudy-winged white fly does not feed on any but the citrus plant, so the precautions to be taken in regard to the other food plants in the case of common white fly do not apply in the case of an infestation of the cloudy-winged white flies only.

15. Woolly White Fly.—The woolly white fly was first described in Cuba in 1891, and was discovered in Tampa, Florida, in 1909. Since then it has spread rapidly and is now pretty well distributed over the southwestern part of Florida and as far east as Orlando. It will undoubtedly soon extend over all of the citrus regions of Florida and ultimately, probably, over the citrus regions of the gulf coast as well.

The adults of the woolly white fly are smaller than those of the other species and have a yellow body. They are more sluggish in habit, and take flight much less readily, a circumstance that retards the progress of an infestation through a grove. They cling tenaciously to the clothes of travelers, which often accounts for their rapid distribution and transportation to great distances. The adult females do not show the marked preference for the young tender leaves as a place to feed and lay eggs which is so noticeable in the case of the other species.

While laying eggs, the female anchors herself by her sucking beak, and, using that as a pivot, rotates about so that most of the eggs are laid in small circles about $\frac{1}{8}$ inch in diameter. The eggs themselves are yellowish brown, in color slightly curved, and lie on their more convex side. Because of the habit of the female in laying her eggs in a circle or in several neighboring circles, in connection with the fact that the newly hatched larvas do not crawl far before anchoring themselves, these insects usually occur in small groups of fifty or more on a leaf. The eggs hatch out in a few days into young larvas that do not have woolly filaments over the body, but fringes of wax are very conspicuous. The insect is brownish in color, smaller in length and breadth than the other species of white flies, but distinctly thicker. Long curved hair-like filaments of wax mat over the larvas in their later stages, completely covering

them and give them a woolly appearance, from which the name is derived. Fig. 15 shows a leaf with mats in twice their natural size. The small circles of eggs can be plainly seen in the illustration. In addition to these long hair-like filaments, the insects are fringed on all sides with a border of waxy plates, and they have a copious secretion of mealy-looking wax over the back.

The larvas also give off a copious secretion of a particularly sticky honeydew, which, in case of a severe infestation, rains down in a shower on the head of one who disturbs the branches. Much of this liquid collects in the wool covering the insect

FIG. 15

and in it there grow several kinds of green and black molds, giving to an old colony a very dirty appearance.

16. Although the red aschersonia fungus has been found on the woolly white fly, it is so infrequent as to be of practically no help in keeping it in check. Luckily, however, there is a tiny wasp-like parasite that destroys a vast majority of them. This parasite lays its eggs in the larva of the white fly. The eggs hatch out into small grubs, which consume the interior of the white fly larvas, so that there comes out of the pupa skins, not adult white flies, but these minute wasp-like creatures, which are yellow in color and about $\frac{1}{25}$ inch in length.

So effective is this parasite that it keeps the woolly white fly well in hand, in the majority of the groves in which it is found. However, the white fly sometimes gets a start in a grove and does a great deal of damage for a generation or two and may destroy or greatly reduce a season's crop, but sooner or later the parasite gets the upper hand and the white fly almost disappears but may reappear again later.

Owing to the woolly coat so matted with honeydew, it is a difficult matter to reach the insect with a spraying solution. In the younger stages, however, they are easily killed by the same miscible oils that are used to combat the other species of white flies.

Another serious feature of the woolly white fly is that it is usually followed by a serious infestation of purple scale. The woolly colony makes a fine place for the crawlers of the scales to hide, and they collect there in large numbers. Therefore, one who has an infestation of the woolly white fly should be prepared to fight the purple scale later.

SCALE INSECTS

17. The scale insects may be divided into two groups, the *armored scales* and the *soft scales*. **Armored scales** are those that have a waxy covering secreted by the insect and under which it lives. The larva begins to secrete wax as soon as it is hatched, forming at first a mealy covering and then a denser yellowish-brown scale under which it lives like an oyster in a shell. The scale is secreted by the insect but it does not become a part of the insect and can be removed.

The purple scale is the most important of the armored scales; the other scales of the armored class are the long scale, the Florida red scale or round scale, the chaff scale, the snow scale, and the California red scale.

The **soft scales** are a class of scales that do not have a scale separate from the insect proper. Scales of this class form a waxy or chitinous covering that is thick on the dorsal side and remains permanently attached to the insect's skin. As the armored scales can be compared to oysters in their shells, so

can the soft scales be compared to turtles whose horny covering is a part of them. These scales are soft only in comparison with the armored scales. All give off more or less honeydew, which is greatly relished by certain large red ants. The grower learns to recognize the presence of these active creatures on his trees as a sign of the presence of either soft scales, aphids, or mealy bugs. None of these soft scales is anywhere near as severe a pest in Florida or the gulf states as are some of the armored scales, but in California the black scale, which belongs to this group, is a more serious pest. The soft scales are more apt to be harmful on nursery stock and on young trees, as they attack only young and tender tissue, especially the young trees. To this group belong the turtle-back scale, the hemispherical scale, the Florida wax scale; the barnacle scale, the mealy bugs, and the cottony cushion scale.

18. Purple Scale.—Next to the common citrus white fly, the purple scale insect is the worst pest on citrus fruits in Florida and in the gulf coast states. This insect is found on leaves, fruit, and smaller branches. Purple scales are sucking insects, and, like the white flies, extract a large quantity of sap from the trees, but, unlike the latter, do not give off honeydew. On the leaves, the purple scales often occur in colonies and may withdraw enough sap to cause the leaves to turn yellow in spots, and they soon after fall off. This yellowing in spots is very characteristic of a severe infestation of purple scale, and the discoloration involves both surfaces of the leaf. The young crawlers also infest the fruit and puncture the rind, making a wound that gives a place of entry for fungi that cause decay, thus doing a great deal of indirect injury. The extent of the stem-end rot in a grove has been proved to bear a direct ratio to the number of scales present under the calyces of the fruit. If abundant, they seriously interfere with the growth of a tree and may even kill it.

19. The adult female scale is oblong, about $\frac{1}{4}$ inch long when full grown, and has the shape of an elongated oyster or trumpet; it has no wings and remains stationary. The adult male scale, on the contrary, is winged and the scale covering

the immature insect is long and somewhat narrower than the scale covering the female insect. The male flies about for a short time, fertilizes the female, and then dies. The male insect, for this reason, is not often seen and does little damage directly to the trees.

In Fig. 16 is shown an orange leaf with a severe infestation of purple scale, which are shown in twice their natural size.

FIG. 16

Eggs for the first brood are deposited in the early part of March by the female under her scale at the posterior end of the body, which shrinks as the eggs are laid, until only the dead and shriveled remains of the body, are to be found under the anterior end of the scale. The eggs are oval in shape, whitish when freshly laid, but soon turn purple. They are to

be found under the old female scale, where they hatch in about a week into small, six-legged, pale-colored creatures, oval in outline, but flat. These crawlers are provided with eyes and antennæ as well as legs and other organs of well-developed insects. They are barely visible to the unaided eye. The young crawlers avoid the light, which leads them to crawl under other things on the leaf such as the woolly white fly. A favorite location also is under the dried calyx of the fruit, where the insects puncture the rind.

The young crawlers find a satisfactory place within a few hours after they are hatched and insert their sucking mouth parts, or beaks. The female remains stationary throughout her existence. If the female insect is forcibly torn away from her feeding place, she cannot reinsert her beak and perishes from hunger. The male insect is winged when adult and can move about. In from 8 to 20 days the insects outgrow their scales and produce a new scale, by a process known as molting. The old scale is not discarded, but on the contrary, it is used as the foundation for the new scale material, which is added to the posterior portion. This new material is darker in color than the first scale, which, throughout the life of the insect, can be recognized as a lighter area on the anterior end. The insect no longer possesses legs, eyes, or antennæ; indeed, it could hardly be recognized as an insect at all were its life history not known. Now for the first time the sexes begin to appear different, the scale that covers the male being shorter and thinner than that covering the female.

Some 3 weeks or more after the first molt, the males molt again and about 1 week later the females do the same. There is now a marked difference in the appearance of the sexes. The male is in the pupal stage and a week later comes forth as a two-winged insect and soon flies off to mate with the female, which is now in the third stage, but differs little from the second stage except in size. The female never becomes a winged insect but grows rapidly and at the age of 9 or 10 weeks begins to lay eggs.

The above periods of time hold for summer weather only. Development is much slower in winter. There are three or four

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generations each year. These broods are not well separated, all stages being found at almost any time. There are, however, certain periods when crawlers are most abundant; these periods are March or early April, June or July, and September or October.

20. Like the white flies, the armored scales are, in the gulf-coast region, much infested with parasitic fungi, especially during the more humid periods of the year. There are three fungi which are chiefly concerned in keeping down the purple scale. These are the red-headed scale fungus, the gray-headed scale fungus, and the black scale fungus. In addition to these, the white-fringed fungus, the turbinate fungus, and the cinnamon fungus are occasionally found as parasites on the armored scales. The red-headed scale fungus is first noticed as a little, curved, scarlet horn protruding from under the edge of the scale and curving upwards. This is the fruiting body of the fungus and is only about $\frac{1}{8}$ inch long. If the scale is dissected and examined under a microscope it is found to be permeated by the filaments of the fungus, which often extend for a little distance beyond the scale. The gray-headed scale fungus ends in more of a head-like swelling and when fresh is light gray in color, but turns to a brown color as it gets older. The characteristic club-like swellings of the gray-headed scale fungus are shown in twice their natural size in Fig. 17. The black scale fungus is most often met with on the trunk and branches of a tree, where it forms a black mass as shown in Fig. 18.

FIG. 17

These parasitic fungi, although more abundant in the summer than at other times, are more apt to work throughout the winter than those that are parasites of the white flies and they are even more efficient in keeping down the scales. So important are these parasitic fungi that if they are destroyed as happens when the trees are sprayed with Bordeaux mixture to kill injurious fungi, the purple scales at once increase to such an extent as to severely damage or even kill the trees unless prompt measures are taken. If it is absolutely necessary to spray the trees with Bordeaux mixture or other similar fungicide, the grower must follow it soon with an insecticide or there will surely be trouble with the purple scales.

The grubs of a wasp-like insect also aid in the control of the purple scale. The wasp-like insect lays its eggs in the scales, and the eggs hatch out into white grubs that consume the scale insects and their eggs and then change to the adult wasp-like form and escape through a round or oval hole in the top of the scale. The ladybird beetles, of which the twice-stabbed ladybird beetle is the most important, are another aid in the control of the purple scale, as they eat large numbers of the crawlers. The mature form of the ladybird beetle is shown at the left in Fig. 19, and at the right on twigs are shown empty pupa cases from which the beetles have crawled.

FIG. 18

21. The methods of control for the purple scale are much the same as those practiced for the control of the white flies. Fumigation, spraying with the heavy oils, and the introducing and spreading of the parasitic fungi, will tend to hold the purple scales in check. Fumigation for the purple scale alone is not used in the Florida citrus belt except on nursery stock. The

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same method of control is employed as for the white flies. The miscible oils which are used against the white flies are also the best insecticides for use against the purple scales. They do not, however, kill the eggs, so that in order to rid the trees thoroughly of this scale it is necessary to spray a second time, from a month to 6 weeks later. In a month after the first spraying, if it is done in the warm weather, or in 6 weeks if it is done in the winter, all the eggs should be hatched out and the young scales will be easily killed by the second spraying; and as the scales do not reach maturity in less than 9 weeks none of the young scales will be developed sufficiently to lay a fresh batch

FIG. 19

of eggs. Not more than 6 weeks should intervene between sprayings, as the scales will be more resistant by that time. Also, it is desirable to avoid the drain on the trees resulting from the withdrawal of sap. If it is not desired to use the oil sprays so frequently, whale-oil soap can be substituted for the second spraying, a pound for each 4 or 5 gallons of water. Whale-oil soap may be used for both sprayings, but the oils are a little more thorough. Spraying twice a year for white flies will usually control the purple scale, particularly, if a good supply of fungi is kept in the trees during the summer. If many scales are present the fall or spring spraying should be followed with a second spraying a month or six weeks later.

What was said with reference to spreading the fungous enemies of white flies applies also to the fungous enemies of the purple scale. Fungous spores can be gathered, preserved, and sprayed by the same methods, and if both the scales and the white flies are present, as is usually the case, both the white fly and the scale fungous spores can be sprayed at the same time.

Except for being found on all varieties of citrus fruits, the purple scale is not often met with outside of the greenhouse, but it occurs on croton, eucalyptus, and on many plants belonging to the rose family.

22. Long Scale.—The long scale is very similar to the purple scale in general appearance; in fact, it is so similar that the average grower does not distinguish between them. Although as late as 1885 the long scale was the more common of the two, it is now very much less abundant. In color it is similar to the purple scale, but in shape it is long and narrow, with its sides nearly parallel, and it is not curved unless crowded. Its life history, parasites, host plants, and control are identical with those of the purple scale.

23. Florida Red Scale, or Round Scale.—Another of the armored scales that does a great deal of damage, particularly in Southern Florida, is the Florida red scale, or round scale. It mostly confines its attacks to the leaves and fruit and as the fruit is picked every season and the leaves are dropped every few years in the more northern region as a result of frost, the red scale has more difficulty in maintaining itself than where frosts are less frequent. It is circular in outline and for this reason is often known as the round scale, or the nail-head scale. In Fig. 20 the Florida red scale is shown on the fruit and leaves of the kumquat. The older part of the scale, which is red in color, can be seen in the center of the adult scale. Its life history is also very similar to that of the purple scale. The remains of the scale of the first larval stage is incorporated into the later scale, as is always the case with the armored scales, but instead of the new material being deposited on one side only, leaving the first larval skin at the

anterior end of the later scale as in the purple scale, it is added about equally on all sides, so that the first larval skin occupies the center of the later scale, as shown in Fig. 20. The scale of the first larval stage is bright red in color and is raised up above the later part, which is dark brown; it is very conspicuous. The male completes its development in about 7 weeks in summer and the female begins to lay eggs when 10 weeks old and continues to do so for 2 weeks. The damage it does is of the same nature as that of the purple scale, but it does not have the latter's tendency to collect in colonies, and hence the whole leaf turns yellow simultaneously and very soon falls.

FIG. 20

24. The Florida red scale is attacked by few natural enemies that do much to hold it in check. The black-headed and gray-headed scale fungi do not attack this scale at all, and the red-headed scale fungi is not as effective as it is against the purple scale. However, there has recently been discovered a pink fungus that promises to do excellent work against the Florida red scale. The light-colored area around the Florida red scale in Fig. 21 illustrates the work of the pink fungus on this scale. Its method of application is the same as for the red-headed scale fungus. The insect enemies are about the same as those of the purple scale. In view of the fact that it is attacked by only a few parasites, spraying must be largely resorted to. The miscible oils are the best insecticides but they do not kill either the eggs or the older scales efficiently. To do thorough

work it is necessary to follow the first spraying with a second in 3 or 4 weeks.

In addition to the citrus plants, the other food plants of the Florida red scale are the camphor, the banana, the magnolia, the oleander, the palms, and the myrtle.

25. California Red Scale.—A scale that has several times obtained a foothold in Florida but has never become a severe pest in the East is the California red scale. It derives its name from the reddish color of the mature scale. It is thinner and less conspicuous than the Florida red scale. The life history and control is the same as for other scales.

FIG. 21

26. Chaff Scale.—The chaff scale is preeminently a scale of the smaller branches, although it is found on the trunk, the larger branches, the leaves, and the fruit. The scales frequently overlap, and, being of a yellowish-gray color and thin in texture, they resemble a collection of chaff. They may cover the branches thickly, but they are apt to be overlooked, because their color is so similar to that of the bark. This scale derives its name from the appearance of the colonies of females, which are the color of chaff. The female scale is about $\frac{1}{16}$ inch in length and nearly as wide. The first larval skin is at the apex and the female is darker in color than the male. It is the smaller male scale, however, that is more apt to reveal its

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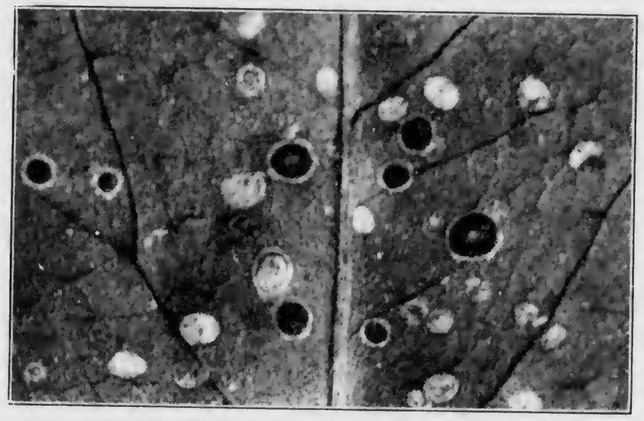

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presence, since it is white in color. The male scale is only $\frac{1}{25}$ inch long and much narrower than the female, and is oblong in shape.

The young crawlers wander about for a few hours, as in the case of the purple scale. They avoid the light, which often leads them to come to rest under a mass of old scales, and accounts for the tendency to collect in colonies. There are five or more generations each year in Florida. The first generation matures in March or April and the last in September or October.

Because of its habit of collecting in colonies, the black fungus does very effective work against this scale. The red-headed scale fungus also attacks it. Wasp-like parasites similar to those that attack the other armored scales work on this one also, as do the ladybird beetles.

Control is the same as for the other armored scales. Chaff scale is so easily controlled by the oil sprays and occurs so spasmodically that it is usually not thought necessary to introduce its fungous enemies. However, fungous enemies prevent many outbreaks and keep the scale down in most groves so thoroughly that the owner does not suspect their presence. This scale is also found on the japonica.

27. Snow Scale.—Another scale that feeds on the bark of citrus trees is the snow scale. This scale prefers the trunk and larger branches, where it may suck the bark so dry as to kill it and cause it to crack. Like the chaff scale, the male scales are white, whence its name; the females resemble the bark in color. The snow scale may be distinguished from the chaff scale by a ridge that runs lengthwise down the middle of the back. The male scale shows three such ridges. Control is identical with that of the chaff scale.

28. Turtle-Back Scale.—The most common of all the soft scales on citrus fruits is the turtle-back scale. It is brown in color and oval in outline, considerably swollen in the middle but flattened out along the margin so as to form a thin edge. It is from $\frac{1}{8}$ to $\frac{1}{16}$ inch long when full grown. The back is ridged and thrown into folds, resembling the sculpturing on a

turtle's back, hence the name. The turtle-back scales are most abundant in the spring and reach the climax in June, after which their numbers rapidly dwindle. This diminution in their numbers is due to the activities of their enemies and to the fact that suitable young wood for food becomes more scarce.

The turtle-back scales are attacked by a number of wasp-like insects that greatly reduce their numbers. Ladybird beetles do good work in holding these scales in check. The white-fringed fungus is frequently a parasite on them. Indeed it is on these scales that it is most apt to form a definite distinct fringe. The heavy oils will easily control the turtle-back scales, as will also whale-oil soap. As in the case of other scales, it may be necessary to spray again at the end of a month. The turtle-back scale attacks a number of other plants, chief among which are ivy, oleander, and japonica.

29. Hemispherical Scale.—In many respects the hemispherical scale is very similar to the turtle-back scale, but is much more swollen, so that in profile it is nearly hemispherical in outline. The enemies and the control are the same as for the turtle-back scale.

30. Florida Wax Scale.—The Florida wax scale is common on the gallberry, a wild plant, and is frequently found on many other plants besides citrus plants. It has even been observed on sweet potatoes. This scale is found on orange trees and occasionally becomes abundant. The scales collect on the leaves, chiefly along the midrib, and particularly on the smaller twigs. The wax scale derives its name from the snow-white waxy covering, which is very hard and brittle.

In Fig. 22 is shown a severe infestation of the Florida wax scale on an orange twig and leaf. The adult is $\frac{1}{8}$ inch long or less. Each female lays from seventy-five to one hundred eggs, which are deposited under her waxy covering; the eggs are $\frac{1}{100}$ inch long or less. The larvas complete their growth in from 3 to 4 months. There are three broods a year, with crawlers most abundant in April and May, July and August, and October and November. However, the broods are not very definite and

some insects, in all stages of development, may be found at almost any season.

The insect enemies of the Florida wax scale are about the same as those of the other scales, but only the turbinate fungus attacks them to any extent. The adult females often fall off of the orange leaves due to their own weight and perish on the ground, as at this stage they are unable to crawl. This shows that the orange tree is not their native home. They seldom become sufficiently abundant to make spraying necessary, but sometimes they do damage to young trees. They can be controlled by the same miscible oils that are used for the other scales. These sprays will kill the young scales.

FIG. 22

31. Barnacle Scale.—The barnacle scale is very similar to the Florida wax scale except in its height, which is equal to its width. The sides rise abruptly from the margin, so that it resembles a barnacle in shape.

32. Mealy Bugs.—In Fig. 23 are shown, in half their natural size, colonies of mealy bugs on grapefruit. The injury they do is very apparent from the illustration. Mealy bugs are dry-weather insects, and consequently they are not the serious pests in the Florida citrus region that they are in the California groves. Usually mealy bugs are most troublesome in the spring, from March to June, which is apt to be a dry

period in Florida. These insects approach the extent of a pest more or less periodically and in many cases will disappear and reappear very suddenly, depending on whether the climatic conditions are favorable or unfavorable for their growth. Rainy seasons have a tendency to hold the mealy bugs in check, and dry seasons are particularly favorable for their increase.

All parts of the tree, including the leaf, branches, and fruit, particularly the fruit, are attacked by this insect. Masses of the insects, eggs, and young may be clustered on the fruit,

FIG. 23

usually in sheltered places as along the midrib or at the junction of a leaf with the stem. A most favorite situation is between two oranges or grapefruit that are in contact. This is particularly annoying in the case of grapefruit, which more frequently grows in clusters. The mealy bug secretes a particularly sticky honeydew, which, with the accompanying sooty mold, results in a most unsightly fruit and one hard to clean. The ordinary washing machine often fails to remove this, and, in the vigorous scrubbing rendered necessary, the fruit is apt to get scratched or bruised, thus making an entrance place for the molds that

cause decay. In addition to this damage, the drain on the fruit and tree resulting from the withdrawal of so much sap is a serious matter.

33. There are all over the Florida citrus section two species of mealy bugs, the common citrus mealy bug and the long-tailed mealy bug. The latter has two long spines that project backwards from the posterior end; otherwise, they are similar in appearance and life history. The full-grown female is about $\frac{1}{6}$ inch long, $\frac{1}{12}$ inch wide, and oval in outline. The male, which is not often seen, is a minute two-winged insect measuring $\frac{1}{10}$ inch across the outstretched wings. The adult mealy bugs, unlike the scale insects, make no thick and hard scale, do not lose their legs, feelers, or eyes, and are able to move about nearly or quite throughout their entire life. They do form some wax, which adheres to them in granules, giving to them their name of mealy bugs. In all these respects, mealy bugs resemble the young crawlers of the other scale insects. In fact, the latter are supposed to have been derived from mealy bug-like ancestors.

The eggs of this insect are laid in a cottony mass secreted by the insect as the eggs are deposited. Each female starts egg laying before full grown, and may lay as many as 350 to 400 eggs. The eggs hatch in warm weather in from 8 to 10 days and in cold weather in from 16 to 20 days. The young crawl about only short distances, as they are busy feeding throughout their entire life. Eggs deposited in March will produce adults in the middle of May, and eggs deposited in the middle of May will produce adults by the first of July.

The mealy bugs are attended by ants to a greater degree than the soft scales. Indeed, ants carry them about and place them in favorable localities and are supposed to protect them from some of their enemies, to herd them, in fact, for the honeydew, or milk, that they produce, so that these mealy bugs, like the aphids, are referred to as ants' cows.

34. The mealy bug, being a soft-bodied insect and exposed on the tree, is subject to the attacks of many parasites and predacious insects. The ladybird beetles and their larvas eat

many of them, and are the most persistent agents in checking them. A predacious caterpillar, the larvas of syrphus flies, lace-winged beetles, trash bugs, wasp-like insects and certain fungi are very efficient in controlling mealy bugs.

Sometimes when mealy bugs become numerous, it may be necessary to apply an insecticide in order to kill them. The most important factor in spraying them is pressure; the particular insecticide used is of minor importance. Indeed, good results are often obtained by the use of water alone if it is applied with sufficient pressure. If they are washed from their hiding places, scattered, and dashed to the ground, very few of them get back on the trees. Better results, however, will be obtained if some insecticide is used. Whale-oil soap in the proportion of 1 pound of soap to 4 gallons of water, or tobacco decoction the same as is used for thrips, as described in a subsequent paragraph, will effectively combat these pests. The best spray is probably that used in California. It is made by dissolving $2\frac{1}{3}$ pints of crude carbolic acid and $2\frac{1}{3}$ pounds of whale-oil soap in a gallon or two of hot water. When it is used it is diluted to make 50 gallons of spray.

35. Cottony Cushion Scale.—The cottony cushion scale is now generally distributed over a half dozen counties in the southwestern part of Florida. It is spreading rapidly and will doubtless in a few years be found all over citrus Florida and ultimately in the gulf coast district as well. This insect has a most interesting history. It was introduced into California from its native home in Australia in 1868. In 20 years it had so over run the groves and killed so many trees that it seemed as if the entire citrus industry of that state was doomed. In desperation an entomologist was sent to Australia in the hope of finding some parasite that would stop its ravages. That there was some such enemy was indicated by the fact that it was not a severe pest in its native home. The entomologist found and brought back the Australian ladybird beetle. This is a very small insect that measures only $\frac{1}{8}$ inch in length; it is of a red color, especially the young. The importation was a great success. The ladybird beetles multiplied rapidly and

soon conquered the scales so thoroughly that they have not given any serious trouble since. The scale was imported into Florida about 1893. Here, as in California, it was finally brought under subjection by the Australian ladybird beetle, which was brought from California. Since then there have been some outbreaks of the scale in various parts of the gulf-coast states, but as soon as they became severe the Australian ladybird beetle was obtained and the infestation checked.

36. The cottony cushion scale is related to the mealy bugs, and the young look and act much like those of mealy bugs. It has the mealy bug habit of hiding in crevices and in the forks of twigs, but it infests the larger branches and the trunk of the tree as well. The adult females, however, have a very characteristic appearance that readily distinguishes them from any other citrus insect. The scale insect is brownish in color and looks much like a soft scale. As the 500 to 800 eggs are laid, there is exuded with them a liquid which, on exposure to the air, swells greatly and forms a soft cushion in which the eggs are found. This cushion tilts up the posterior part of the scale until the insect literally stands on its head. This pure white cottony mass, which may reach a length of more than $\frac{1}{2}$ inch, is ridged lengthwise, which has given to this insect its other name, fluted scale.

The eggs require from 10 days to 2 weeks to hatch, depending on the season. The larvas settle on the leaves and twigs, being most numerous along the midrib and veins of the leaf. As the larvas grow older they show a marked preference for the twigs and branches by migrating there. The older larvas may even be found on the trunk. Unlike the other scales, the cottony cushion female scale travels throughout the greater part of her existence, or at least until the egg sac is secreted. This scale reaches maturity in 3 or 4 months, and there are about three generations a year in the southern part of Florida. The season of greatest production of young is during May and June.

The way to control this pest is to obtain and introduce the Australian ladybird beetles. These can usually be obtained with a little delay from some infested region of Florida or

California. If they cannot be obtained at once or if it is a question of a dooryard tree or two, one of the insecticides recommended for mealy bugs may be used. The insect also attacks roses and some other cultivated plants.

MITES

37. Next to the white flies and scale insects, the most persistent enemies of citrus fruits in the Florida region are three species of mites. These are not insects, but are related to the spider family. They are all dry-weather pests and are apt to be particularly abundant in the spring and early summer before the rainy season sets in. Two of these, the purple mite and the six-spotted mite, commonly go under the name of red spiders. The russet mite, however, is much different in its habits and general appearance. Like all the most serious enemies of citrus fruits, they are sucking pests that withdraw the sap from the trees.

38. Purple Mite.—The purple mite is dark-red in color, $\frac{1}{100}$ inch in diameter and nearly round. It is found on both surfaces of the leaves and on the fruit. When the infestation becomes severe, the leaf turns a uniform grayish green and has a dry appearance. Like most members of the spider family, the purple mite is provided with eight legs when adult. Like other spiders, too, the adult is hairy. If one of the species is examined under a lens the stiff hairs are seen to rise from little wart-like projections. This distinguishes the purple mite from the other species of mites, including the six-spotted mite, and russet mite which lack these projections. The male spiders are smaller than the females and are usually present, but eggs may be produced and young hatched without them, since the female has the power to produce eggs without fertilization. The eggs are minute bodies, nearly spherical, and are red in color; they occur singly and are held firmly to the leaf by fourteen silken guy threads, which are attached to the end of a perpendicular stalk that rises from the upper side of the egg.

The eggs of the purple mite are most abundant during May. From one to six or seven eggs are deposited each day after egg

laying begins. This continues for 4 weeks until a total of from fifty to seventy-five eggs have been deposited. The eggs deposited in a day usually average two or three. However, there may be days when no eggs will be deposited. The eggs hatch in about 10 days to 2 weeks into small larvas that have only six legs. This and the size are the chief differences between the larvas and the parents which have eight legs and are much larger than the larvas. The young mites, as soon as they are hatched, begin to feed, and they come to maturity in about 12 days, during which time they have molted three times at intervals of 3 or 4 days each. After the first molt, the larvas acquire another pair of legs, which is the normal number for most mites and spiders. The female spiders are now ready to deposit eggs again. Allowing 10 days for the hatching of the eggs, 12 days for development of the insects, and 4 weeks for adult life, it is seen that the entire life span is about 7 weeks, although there may be a new generation every 3 or 4 weeks. This quick development accounts for the sudden appearance of a severe infestation in a grove.

39. The mites have many natural enemies, including lady-bird beetles, larvas of the lace-winged flies, the larger spiders and mites, and some species of thrips.

The method of control is the same for the three species of mites. Sulphur in some form or other is the standard remedy for mites. This may be applied dry, in the form of a dust, or as a liquid; and either free sulphur or one of its compounds may be used. A commonly used insecticide is dry sulphur very thoroughly mixed with hydrated lime in the proportions of 3 pounds of sulphur to 1 pound of lime. If it is impossible to secure hydrated lime, this compound may be made by adding sufficient water to quicklime to partly slake it; about 4 gallons to the 100 pounds will be sufficient. The lime is allowed to dry after it is slaked. This hydrated lime can then be mixed with the sulphur. Care should be taken that the mixture of lime and sulphur is finely pulverized. The sulphur and lime may be dusted over the tree by hand, or, better, may be blown through the trees by a rotary bellows. There are several good

bellows on the market. It is best applied in the early morning when the dew is on the trees or after a shower when the trees are wet, since at this time the sulphur sticks to the leaves. It is essential that the dust reach every part of the tree, as the vapor of sulphur is effective only at a distance of a small fraction of an inch; in fact, it is practically necessary to hit a mite to kill it. Since the dust must be very fine to be effective the flowers of sulphur rather than the flour of sulphur must be used.

The sprays, however, will act more quickly than the dust, but unless water is handy and the grower is supplied with a good power spraying outfit it will be much more expensive. Whether one had better use the dust or a spray will depend on many circumstances, including the outfit available, the weather, the severity of the infestation, and the consequent need of rapid results. If spraying is done for other insect pests, the sulphur may be added to most solutions, thus getting the insect and the mites at one spraying. In the case of spraying for white flies and scales, however, it is not necessary to add any sulphur, as the miscible oils will kill the mites also. Some of the most effective sprays are: free sulphur, from 1 to 5 pounds per barrel of water; lime-sulphur solution, from 1 to 4 quarts per barrel; or liver of sulphur (potassium sulphide), in the same proportions.

The remedy should be applied promptly whenever injury is noted or the spiders are seen to be abundant on the trees. During dry weather, especially in the spring, one should be constantly on the lookout for them. A temperature of about 75° is necessary to vaporize the sulphur. A higher temperature will bring results more rapidly. Since heat is required to vaporize the sulphur, it is obvious that, as far as possible, days that are bright and warm during the middle of the day should be chosen for the application of the sulphur.

40. Six-Spotted Mite.—Frequently on the lower surface of the leaves will be found mites known as six-spotted mites. These mites are usually along the midrib and extend outwards and forwards in the direction of the cross veins. The adult insect is pale yellow in color and has six dark spots on its

body, from which it derives its name. As was said before, the six-spotted mite confines itself to restricted areas. Sap is withdrawn from the leaves, which causes them to turn yellow in spots where colonies of mites are located. On the surface of these yellow spots can be found old cast skins of the insects, covered with a web. The web is more or less conspicuous under a lens. The upper surface of the leaf is swollen upwards, corresponding to the depressions on the lower surface and the area is smooth and pale yellowish in color. This spotting with yellow is very different from the uniform gray appearance which follows the work of the purple mite. If sufficiently injured, the leaves will drop. The six-spotted mite is not so injurious as the purple mite.

The life history of the six-spotted mite is similar to that of the purple mite, and the enemies and methods of control are the same for both.

41. Russet Mite.—The russet mite is different both in appearance and in work from the six-spotted and the purple mite. It attacks both fruit and foliage, but the injury is most noticeable on the fruit. The contents of the oil glands on both the fruit and the leaves are sucked out. This injury results in a russet color on the fruit and a gray color on the leaf. The leaf, if sufficiently injured, will become dry and die. It is the injury to the fruit which usually attracts the attention of the ordinary grower. The keeping and shipping qualities of the fruit are not seriously injured and the flavor is actually improved. A russet orange is sweeter and more juicy, and, because of the thinner rind, the purchaser gets more fruit in his box. But the market demands a bright orange, and as russet oranges bring low prices, it pays well to combat the russet mite.

The russet mite is shaped like an elongated triangle, that is, it is widest at the head and tapers at a nearly uniform rate to near the posterior end. It is only about $\frac{1}{200}$ inch in length and practically invisible to the unaided eye. Under a lens it is seen to be of a light yellow color and to possess but four legs.

The eggs, which are pale yellow in color, are laid singly or in small clusters on leaves and fruit. They hatch out in from 4 to

5 days in summer and in from 10 to 14 days in winter. The young larva begins to feed at once and in about a week sheds its skin, or molts, passing into the adult stage. In summer weather the entire life history consumes less than 2 weeks; in colder weather this period may be doubled.

The enemies are about the same as for the other mites, and in addition a species of syrphus fly attacks them. The control is the same as for the other mites.

MISCELLANEOUS INSECTS

42. Large Plant Bugs.—There are several species of large plant bugs that occasionally do a great deal of damage by sucking the juices of the ripening oranges and of the young and tender sprouts on the trees. The orange, if sufficiently injured, will fall off and be ruined as far as shipping is concerned. The injury due to the insects sucking the sap from the branches is insignificant on old trees, but on young trees or nursery stock it is more important, since new growth is retarded.

The fact that these bugs attack citrus fruits is mainly due to the management of the leguminous cover crop. They prefer legumes to almost any other food and will not attack orange trees unless the legumes fail them. Frequently the cover crop of beggarweed or other legume is allowed to remain on the ground until the bugs have completed their growth and passed into the winged stage. The result is that when the cover crop is cut, the adults have no legume to feed on and go to the orange as the only thing left for them.

There are a half dozen bugs that commonly attack the fruit and tender shoots of the orange tree. In the approximate order of their importance they are: the pumpkin bug, a green bug that is over $\frac{1}{2}$ inch long and very common; the smaller leaf-footed plant bug, a dark-brown insect with a yellow band across the hind wings and the hind legs expanded into wide, leaf-like structures; the cotton stainer, a large dark-red bug that frequently injures cotton and sometimes attacks citrus groves; the common brown stink bugs; and the giant leaf-footed plant bug, a grayish brown bug that is over an inch in length.

43. In order to control these plant bugs, proper management must be given to the leguminous cover crops grown in the grove. The cover crop should be cut before the bugs have become winged, which will usually be early in September. The herbage around the trees is cut first, and that in the middle of the rows is left until a few days later. This will draw the bugs away from the trees to the middle of the rows, and when this is cut most of the bugs will be unable to reach the trees and will perish. The bugs may be sprayed or collected at these catch centers at a minimum of expense. If, however, the cover crop has been allowed to stand until the bugs are in the winged stage, and they are abundant, it is best not to cut it until the day before the fruit is picked. Also the weeds around the edge of the grove should be kept cut, particularly thistles, as these are the plants on which the giant leaf-footed plant bug feeds. Precautions of this nature will tend to reduce the numbers of the plant bugs and at the same time keep them away from the fruit.

Sometimes when the necessary precautions against these insects have not been taken, they get on the trees. If the damage to the fruit is very great the fruit should be picked at once if it is not too green. If the fruit is too green to be picked, the bugs will have to be collected if anything is to be done to prevent damage. On cool mornings the bugs are very sluggish and may be shaken or jarred on to a canvas sheet placed beneath the tree, and they must be quickly collected from this sheet. It will sometimes pay to rig up an apparatus consisting of a framework of wood or metal in the shape of an inverted umbrella, which is covered with a piece of canvas that has a slit in it so that the frame can be placed around the trunk of the tree at the bottom. At the center of the canvas there is a hole under which is placed a pan containing water, on top of which is a layer of kerosene. In the early morning or on a cool day, at which time the bugs are sluggish, they may be shaken on to the canvas, and they roll down the sides and into the pan of kerosene and are killed. This method of combating bugs is quicker and cheaper than any possible insecticide treatment. Contact insecticides have little effect on the plant bugs, because

they are large and the covering of their bodies is hard. Contact insecticides that will kill the plant bugs can be had, but they are of such strength that they would kill the plant also. The cotton stainer may often be successfully combated by distributing baits of poisoned cottonseed meal in various parts of the tree. The insect seems very fond of this poison. Such a poison bait can be made by mixing thoroughly 1 part of Paris green with 25 parts of the cottonseed meal and moistening the mixture with water to which sweet syrup has been added.

44. Thrips.—Oftentimes if the blossoms of the oranges are shaken in the hand, many small yellowish insects known as thrips can be seen running about. The thrip insect is illustrated in Fig. 24. These insects feed on blossoms, leaves, and fruits, but preferably on the pollen and petals, and are usually found in the interior of the orange and other fruit blossoms. If not too numerous, thrips do little harm; if they are abundant they attack the pistil as well and cause the blossom to drop. In years of abundant bloom even this does little harm, as there are many times more blooms than can possibly set fruit. In years of scanty bloom, however, or when thrips are unusually abundant they may ruinously shorten the crops. After the blossom has cast the petals and other temporary structures it is a common occurrence for them to feed on the developing pistil or on the young orange, from which they scrape the epidermis. Thrips often work around the stem of fruit and make a distinct ring of rather irregular outline, sometimes also working down in streaks along the sides of the fruit. The wounds are usually shallow and do not

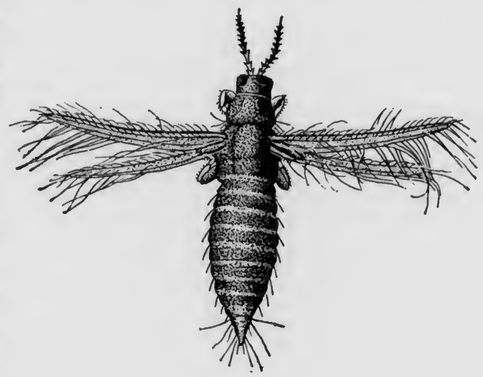

FIG. 24

greatly retard the development of the fruit, but they produce smooth, shiny areas, which are referred to as silvery scurf, or thrip marks, which are illustrated in Fig. 25. These marks hurt the appearance of the fruit and prevent it from being sold as first class.

The adult thrip is a very small four-winged insect about $\frac{1}{25}$ to $\frac{1}{30}$ inch long and $\frac{1}{100}$ inch wide. The color ranges from yellow to orange. Thrips can be very readily recognized by their ability, when disturbed, to jump long distances in proportion to their size. Under a lens the wings are seen to consist

FIG. 25

of a true membrane, which is lined on all free sides by hairs several times longer than the width of the membrane. Adults appear in early spring and there is a succession of broods until November.

The females lay their eggs in slits they make in the soft tissue on which they feed. The eggs hatch in from 3 to 4 days. The young are similar to the adults but they have no wings. In favorable weather they attain their full size in 9 days; thus, there is a generation in only 12 or 13 days.

45. Tobacco or any of its compounds is a cheap and efficient remedy for these insects. A tobacco compound can be prepared at home by boiling stems or refuse tobacco in water until a solution the color of weak tea is obtained, or the commercial product can be purchased already prepared. There are several of these commercial preparations on the market which are sold under various trade names. The most popular and the best tobacco preparation on the market is a product sold under the name Blackleaf 40. The 40 signifies a strength of 40 per cent., which is a very concentrated solution. A good formula is: Blackleaf 40, $3\frac{1}{2}$ fluid ounces; commercial lime-sulphur, $2\frac{1}{3}$ quarts; and water, 50 gallons. It is desirable to put lime-sulphur or soap in the solution, since this causes the tobacco to spread well and at the same time retards evaporation; also, it causes the tobacco to stick more closely to the leaf. To obtain the same results in spraying with the home-prepared product, 5 gallons of tobacco solution must be substituted in the preceding formula. Also, any of the fish-oil soaps, such as whale-oil soap, may be substituted for lime-sulphur in the preceding formula. From 2 to 5 gallons of the soap solution should be used, depending on whether the water is soft or hard. This spray should be applied, in case thrips are numerous, while the trees are in bloom, and the spraying should be repeated at intervals of 10 days until the pest is under control. A strong pressure of 175 pounds is desirable, so that the spray may be distributed evenly over all parts of the tree.

46. Aphids.—Often early in spring, aphids can be found thickly covering the under side of the young leaves of citrus trees. These small insects cause the leaves to curl and check the growth of the young, tender shoots. Since the attacks of aphids are confined to a few shoots, the effect on the whole tree is not serious. Fortunately, these plant lice are greedily eaten by ladybird beetles, trash bugs, syrphus flies, and the maggots of a wasp-like insect. The adult wasp-like insects lay their eggs in the aphids. These hatch out and cause the aphid to swell until it is nearly spherical. After the death of

the aphid the parasite cuts a circular hole in the body of the aphid and emerges through the opening as the adult wasp-like insect.

These enemies keep the plant lice so well in check on citrus plants that it is seldom necessary to use insecticides. Should they become so abundant as to threaten to check the growth of the trees, which will seldom be the case and then only on the very young trees that have few leaves, they can be readily controlled by the tobacco extracts, as explained for thrips.

47. Orange Dog.—Frequently large disagreeable looking caterpillars, known as orange dogs, may be seen feeding on the leaves of citrus trees. These caterpillars are about $2\frac{1}{2}$ inches long, gray in color, and marked with dark blotches of a dirty white color at the posterior end. When irritated, the caterpillar protrudes a forked bright-red colored horn and at the same time secretes a substance with a very disagreeable odor. The appetite of the caterpillar is enormous. Much damage may be done in a short time, and especially on young trees, if these caterpillars become numerous. Fortunately, they are seldom very abundant

When full grown the larva hunts a secluded place in some log, fence, or on a limb and enters into the chrysalis stage. After about 14 days the adult emerges as a gorgeous black and yellow butterfly about 6 inches across the expanded wings, with long, tail-like prolongations on its hind wings. The yellow markings form two bands, the upper one crescent shaped and the lower one almost semicircular. Each female deposits from 400 to 500 eggs, which are laid on tender shoots.

The caterpillars are so conspicuous that usually the easiest, cheapest, and quickest way to get rid of them is to pick them off by hand, and either crush them or drop them into a pan of kerosene. If they are unusually numerous or if they are accompanied by many other biting insects, they may be poisoned by an application of lead arsenate, at the rate of 3 pounds of arsenate paste to 50 gallons of water.

A cheaper arsenical insecticide, zinc arsenite, can be substituted if desired; this is used at the rate of $1\frac{1}{2}$ pounds of the

powder to 50 gallons of water. This spray, however, does not stay suspended in the water nearly so readily as does the lead-arsenate paste. In the use of all arsenical sprays, a little soap mixed in with the solution will cause the insecticide to spread over the leaves and adhere more closely to them.

48. Hag Moth.—Another caterpillar similar in its work to the orange dog is the larva of the hag moth. This caterpillar is the larva of a moth that is rarely seen, because it flies at night and is comparatively rare. The moth is dusky purple brown and has patches of an ocher color on the back and a light yellow tuft on each middle leg. The fore wings have pale yellowish brown markings on them and are crossed by a narrow, wavy, curved band of the same color. The hind wings are sable colored and in the female are bordered with yellow. The larva is one of the oddest known. It is nearly square, dark brown, and bears eight singular fleshy processes projecting from the sides. These processes are half as long as the larva itself and are covered with feathery brown hairs, among which are longer black, stinging hairs. These hairs are curiously twisted so that they resemble locks of hair and give the name hag moth to the species. This larva does practically the same damage as the orange dog and may be treated in practically the same manner, except that they cannot be collected with the naked hands, since they are provided with stinging hairs that irritate the skin.

49. Grasshoppers and Katydids.—It is not often that grasshoppers and katydids do much damage to citrus fruits. There is one species of grasshopper, the large bird grasshopper, that sometimes, when its natural food supply is scarce, will feed on the fruit and foliage of citrus trees. They most frequently feed on the outer rows of trees in the grove where they adjoin grass fields. If the hoppers become numerous, which is rather infrequent, they will spread through the grove and do considerable damage. The principal damage is done to the fruit, due to the insect biting a small area out of the rind. This area enlarges and presents a rough, scurfy appearance. The flavor or quality of the fruit is not injured in any way, but

such fruit must be classed as seconds or as culls. These insects can be poisoned by some arsenical compound or they can be picked by hand on cool mornings when they are very inactive and dropped into a pan of kerosene.

50. Bag Worm.—A common insect in the citrus groves of Florida is the bag worm. In Fig. 26 is shown the case of a bag worm suspended from a branch. The presence of this insect in the grove can always be detected by the peculiar shaped cases in which the insect spends the winter. The cone-shaped cases are made of little sticks and rubbish fastened together by silken threads. The bag worms eat the leaves to some extent and sometimes scar the fruit, as illustrated in Fig. 27, but fortunately they are not usually abundant enough to be worthy of notice. In case it should be necessary to resort to measures of control, they may be poisoned by the same arsenicals that are used for other biting insects.

FIG. 26

51. Ants.—In Southern Florida the leaf-cutting ants and in Louisiana the recently introduced Argentine ant, does damage to orange trees, the former by cutting and carrying away the leaves. These ants can be effectively controlled by trailing them to their nests and treating the nests with a solution of potassium cyanide. A hole is made in the middle of the nest and into it is poured a few ounces of the solution, which consists of 1 ounce of potassium cyanide to 1 quart of water. The fumes given off will penetrate the hill and kill all the ants present. If the nest is near enough to the tree for the liquid to reach the roots it must be used cautiously. Potassium cyanide is one of the most powerful poisons and must be handled with care. In case the nests cannot be found, the insects may be kept from the trees by banding them with some sticky tarry

preparation. The commercial substance sold under the name of tree tanglefoot, coal tar, asphaltum, or any other substance may be used. To avoid injury to the tree by these preparations a heavy paper is closely fastened to the tree so that the ants cannot get under it, and the substance is applied to this. Cotton or wool soaked in oil or vaseline is also good to prevent the ants from getting up into the tree.

52. Termites, or White Ants.—The white insects that look much like true ants except for their color are usually

FIG. 27

called wood lice in Florida. They are very common in rotten wood, on which they feed. If such wood, which is often piled in groves to be burned during a cold spell to fight off frost, is piled too close to the trunk of the fruit tree the termites may attack the bark and even girdle the tree. The obvious remedy is to remove such material from the immediate vicinity of the tree.

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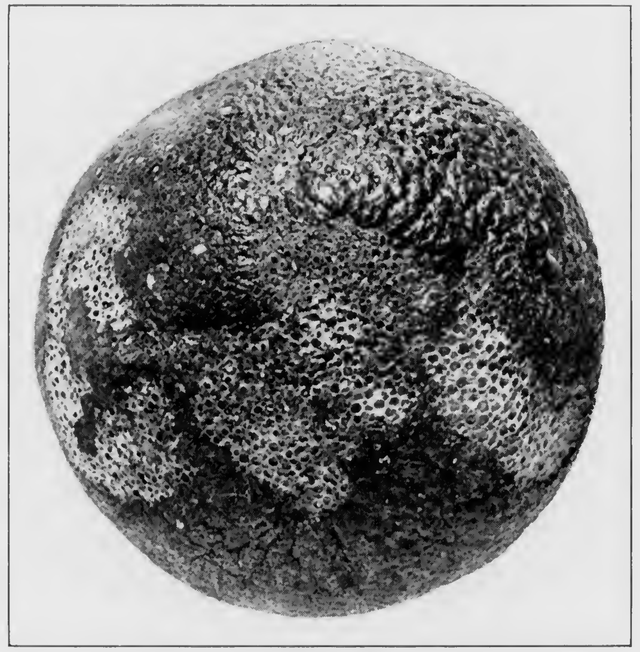

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53. Orange Tortrix.—Almost all citrus fruit growers are familar with a small insect known as the orange tortrix, which bores a small hole through the peel of a grapefruit or orange in which it lives. The orange tortrix is an almost hairless caterpillar of a very small moth. This worm is about $\frac{1}{2}$ inch long, of pinkish color, and resembles somewhat the worm of the codling moth found in apples, to which indeed it is remotely related. It never enters the pulp of the fruit. This distinguishes it at once from the orange maggot of Mexico and the larva of the dreaded Mediterranean fruit fly, which exists in the Hawiian Islands, Bermuda, Southern Europe, and other regions. Although the worm does not enter the fruit, the hole makes an easy road for the entrance of the fungi that cause decay. A wormy orange or grapefruit cannot be shipped, as it would surely decay before reaching the consumer. It some groves as much as 1 per cent. of the fruit is damaged, but usually the damage is insignificant. The collection and destruction of the wormy fruit with the contained caterpillar will be sufficient to control the insect.

CITRUS FRUITS IN GULF-COAST STATES

(PART 4)

INSECTS AND DISEASES INJURIOUS TO CITRUS FRUITS (Continued)

DISEASES OF CITRUS FRUITS

INTRODUCTION

1. The number of diseases affecting citrus fruit is not nearly so large as the number affecting some other groups of fruit. However, the diseases are of sufficient importance to warrant the attention of every citrus grower.

The term disease, in its broadest sense, applies to any condition that interferes with the normal growth and development of a tree; more specifically, the term applies to any condition that results in the decay or death of any part of the tree—the roots, trunk, branches, or leaves. Some diseases result in a general debility of the whole tree without any well marked symptoms. This is most apt to be the case when the disease is due to unfavorable moisture, food, light, temperature, or soil conditions.

Some diseases of the tree are due to ignorance, neglect, or maltreatment on the part of the grower, and frequently trees are injured by wind, excessive heat, or frost. The injured parts, either through neglect or ignorance of the grower, never receive any care or attention, with the result that wounded areas become

infected with disease, which sometimes causes the death or decay of the tree. Bruises due to careless workmen around the tree and improper pruning are often the causes of many diseases. Too often limbs are removed from trees in such a way that a stub is left that will never heal over. Wounds of this nature and bruises in the bark of the tree provide favorable conditions for the growth of fungi, and for this reason are frequently infected and become diseased.

Other diseases are intimately associated with the condition of the soil in which the tree grows. The soil may contain too little or too much moisture. Also the soil may be lacking in proper kinds and quantities of plant-food. When soil conditions are not favorable, trees do not develop properly, and become diseased. Trees in a weakened condition are also very susceptible to attacks from parasitic diseases of a fungous nature. Also, insects that live on trees exert a marked influence by weakening them and therefore rendering them susceptible to disease.

Many of the diseases are due to the attack of fungi and bacteria. Such diseases usually have well marked symptoms by which they may be recognized. The usual symptoms are the dying of the roots and limbs, the spotting of the fruit and foliage, the formation of cankers, or dead areas on the bark, the decay of the fruit, etc. Fungi are very low forms of plants; many of them are useful in helping to break down organic matter into simpler forms for the use of plants as foods, but some of them are parasites that are capable of entering the live tissue of plants and causing disease. Fungi are propagated by means of invisible seedlike bodies known as spores, which may be carried by wind, insects, and birds. The cloud of dust formed when a blue-molded orange or lemon is disturbed is made up of millions of these spores. Each one is invisible to the unaided eye, but in a mass they appear as dust. The spores germinate in favorable conditions of moisture and food material and grow into a network of filaments, or threads, known as a mycelium. In many cases the mycelium is invisible inside the tissue of the plant, but in the case of some fungi the growth caused is visible under the bark. The mycelium gives rise to the spores again and so on over and over again from spore to mycelium.

2. In combating diseases, preventive measures are most important and consist in removing, so far as possible, the causes that operate in bringing on the disease. It is, therefore, important to know the cause or causes for any specific disease before a remedy can be applied. For most of the diseases the causes are known, but the causes for others have not yet been found. Many of the conditions causing disease are under the control of the grower, but by no means all of them. With proper care and due expenditure of money the soil conditions for the growth of the tree can be improved, and these will tend to make the trees resistant to the attacks of disease. Also, all parts of the tree may be covered with some preparation, as a spray, that will prevent the fungi from entering the tree.

3. In general, diseases may be divided into two classes: (1) Fungous diseases, or those due to parasitic organisms such as fungi or bacteria; (2) Physiological diseases, or those due mainly to malnutrition.

FUNGOUS DISEASES

4. Withertip.—The term withertip has been applied to a disease caused by a fungus that attacks the tips of small branches and twigs and causes them to wither and die. The characteristic symptoms of this disease are most pronounced on the new foliage of the lime tree. The new twigs are blackened and wilted in appearance. The young lime fruits are also attacked by the fungus and either drop as a result of the disease or are very badly disfigured by scabby spots over the surface of the fruit. Withertip interferes greatly with the growth of lime trees and with the setting of fruit in Southern Florida and Cuba.

On other varieties of citrus withertip usually manifests itself by a falling of the leaves on certain branches. If the disease is in an active condition the bare limbs from which the leaves have fallen will be seen to be gradually dying back. The bark that has been dead for some time, and such bark is found near the trunk of the tree, will be considerably discolored and stained. Sometimes the smaller branches of orange and pomelo trees are

killed back so rapidly that the leaves shrivel up on the branches before they fall off. It is seldom, however, that the disease kills the branches so rapidly. Fig. 1 illustrates the effects of withertip in killing back small branches.

5. Control measures consist in pruning out the affected twigs and branches and destroying them. The pruning should be done preferably in December and January, while the trees are dormant. However, if it becomes necessary to prune during the growing season it should be done in July after the first growth has hardened; pruning should not be done while the tree is growing vigorously. Not only the dead branches should be pruned out but also all the branches that show a slight sign of the disease. Sometimes only one side of a tree or only one branch is severely affected, and the rest of the tree is uninjured. The distance to which the disease has progressed can frequently be detected by the presence of new shoots that have a sickly yellow color. In pruning smooth cuts should be made, usually at the base of a limb, in order that no stubs be left on the tree. The larger wounds should be painted with either carbolineum, pine tar, grafting wax, or asphalt paint made with benzine; turpentine should not be used in making the asphalt paint, because it causes the paint to harden too rapidly.

FIG. 1

The young developing foliage and fruits may be protected by spraying with Bordeaux mixture. Bordeaux mixture tends to kill the parasitic fungi that keep down scale insects. For this

reason it should be used only when absolutely necessary, and when used should be followed some weeks later with a good insecticide to keep the scale insects in check.

The withertip disease on citrus varieties other than limes is brought on or aggravated by conditions unfavorable for the growth of the tree.

6. Anthracnose.—The fungus causing anthracnose makes itself known to growers by a spotting of the fruits. Anthracnose is due, apparently, to the same fungus that causes withertip and is apt to occur on trees that are affected with withertip. The disease manifests itself on the fruit, in sunken areas that are brown or dark in color. The infected areas may be as small as a pinhead or they may be larger and irregular in outline. The fruits rarely become spotted before they begin to color.

In Fig. 2 is shown a grapefruit affected with anthracnose. The various sizes of the spots can be plainly seen in the illustration.

FIG. 2

Since anthracnose usually accompanies withertip of the branches, the same control methods may be used in combating it. During seasons that are unusually favorable for the development of the fungi it may be necessary to spray the fruit with a fungicide. Ammoniacal solution of copper carbonate has been used with a certain degree of success in controlling this disease. The spray should be so applied that the fruit will be covered and so far as possible the larger limbs and trunk avoided. This will save part of the parasitic fungi that are so helpful in controlling the scale insects. The spray application should be repeated in 10 days or 2 weeks.

7. Tear Streaking.—A reddish-brown to dark-brown discoloration is often seen on the surface of citrus fruits. Frequently the discoloration runs down in a streak as if the dew

or rain drops had carried a stain with them. This discoloration is usually spoken of as tear streaking or as *tear stain*. In Fig. 3 is shown a grapefruit affected with tear streaking. The streaks can be plainly seen on the surface of the rind.

Tear streaking is another manifestation of the fungus that causes withertip. A dead twig affected with the fungus that causes withertip is usually found hanging over such a stained fruit. The fungus spores from the dead twig are carried down

FIG. 3

over the sides of the fruit, where they germinate and cause the discoloration. This discoloration usually begins any time after the fruit begins to color.

The control measures recommended for anthracnose will also prevent tear streaking.

8. Verrucosis.—The disease known as verrucosis, or *scab*, affects the fruit and leaves and sometimes the tender shoots. It is caused by a minute parasitic fungus that grows in the tissue of the part attacked. The fungus grows from a spore, or seedlike body, about the shape of a grain of wheat, but it is so small that it is invisible to the unaided eye. Filaments grow out

from these small spores and penetrate the epidermis of the fruit or leaf and injure the growing tissue.

The fungus attacks the sour orange and the lemon most severely and frequently causes the fruit to grow misshapen and unsightly. Sometimes the fungus manifests itself the same way on the Satsuma orange, though less frequently. Corky projections that range in color from dark gray to tan extend out from the surface, giving the fruit a warty appearance. In Fig. 4 is shown an immature grapefruit that has been affected with scab. The corky projections are visible in the illustration. Between these corky projections the skin retains its normal color. Often these irregular corky projections coalesce and form a large raised corky scab. The attacks of this fungus are less severe on the grapefruit and the tangerine than on the sour orange and the lemon, and rarely is the sweet orange attacked.

FIG. 4

In less severe attacks, especially when the disease is on grapefruit, in place of the warty projections the fungus manifests itself in more or less raised flat patches, the surface of which will be lightly scabbed. These raised areas are variable in size and shape.

The disease also affects both surfaces of the leaves just as they are unfolding and can be detected by the minute light-brown spots that appear. These spots are depressed on one side and are raised on the other. Later, these spots become dark brown or pinkish in color and may grow together, forming irregular corky scabs. This disease is more serious on grapefruit in southern Florida than in the northern part of the state, and is quite troublesome in Cuba, and the Isle of Pines. Scab is not known to occur in California, probably because the climate is too dry.

New growth coming out at unseasonable times and the late bloom, known as June bloom, are most apt to be attacked by

the fungus causing scab. Such growth can be pruned out and destroyed, which will help to prevent a recurrence of the disease. All sour orange or worthless lemon trees in a grapefruit grove should be cut out or budded over, as they are almost always affected with scab and spread the disease to the grapefruit trees or to other varieties of citrus that are susceptible to it. All scabbed sour oranges or lemons should be picked up and destroyed. In very moist situations where scab is severe from year to year the fruit may be protected by spraying with any of the commonly used fungicides, as lime-sulphur solution, ammoniacal copper carbonate, or Bordeaux mixture. The lime-sulphur is usually preferred, since it is also of considerable value in killing scale insects and mites. The first spray should be applied soon after the petals fall and a second application should be made from 2 to 4 weeks later; a third spraying will not often be necessary. The tissue as it becomes older becomes entirely immune to further attack of the fungus. In moister sections where parasitic fungi are present and are efficient agents in controlling scale insects and the white flies, the use of fungicides is often followed by a rapid increase of these insects, due to the killing of the parasitic fungi.

FIG. 5

9. Melanose.—A disease of fungus origin known as melanose is frequently found on the fruit, leaves, and young stems of all varieties of citrus trees in Florida. It is perhaps most noticeable on the grapefruit because of the smoothness of the skin of the normal grapefruit.

The disease was first noticed in Florida in 1892. It has since been reported in Australia, Porto Rico, and Algeria. It is not known to occur in California.

Melanose manifests itself as a superficial marking on the surface of the fruits, leaves, and stems. Fig. 5 shows the melanose markings on the surface of a citrus leaf. In Fig. 6 is shown melanose markings on a section of a grapefruit. Notice how the markings run together in certain areas, giving the surface of the fruit a russet color. The most noticeable manifestations are those that appear on the skins of the fruits.

The markings are small raised areas with a waxlike appearance that vary in color from yellow to brown; sometimes they are almost black. They resemble very closely small drops of melted sugar burned to a reddish-brown color; the markings have a dull sheen. The individual marks vary in size from a mere point to areas $\frac{1}{16}$ inch in diameter. If examined under a hand lens, lines of breakage around the margins and across the surface can be seen and give the appearance on a miniature scale of dry cracked mud.

FIG. 6

When the markings are very numerous the surface of the fruit assumes a russet appearance, which differs from the russeting due to rust mite by having a pronounced roughness that feels like sandpaper to the touch; also a slight peeling of the skin is sometimes noticed in severe cases, which gives the surface a flaky appearance. These markings may be distributed irregularly over the surface of the leaves, fruit, or branches, or they may coalesce, forming solid patches of irregular outline. Frequently the markings occur in half circles or in areas that resemble closely the tear streaking caused by the withertip fungus. Sometimes the fruit may be stunted in growth. The markings do not penetrate into the rind and the edible quality is not impaired, but the unsightly appearance of the surface of the fruit lessens its market value.

Melanose is caused by the same fungus that causes stem-end rot of citrus fruits. The fungus lives most naturally in dead

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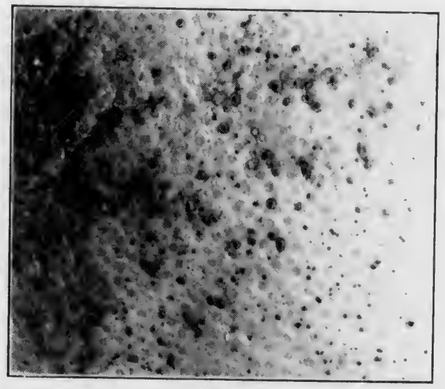

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Melanose is caused by the same fungus that causes stem-end rot of citrus fruits. The fungus lives most naturally in dead

branches and even in very small twigs, where in moist weather it produces countless numbers of minute spores. These spores are produced in small bodies in the bark and to the unaided eye look like dark specks or minute raised pustules on the surface of the dead bark. The fungus is probably spread in the tree chiefly by dew and rain. The spores are washed down from the dead twigs to the fruit, leaves, and new growing twigs. Birds and insects are also, no doubt, instrumental in carrying the spores from tree to tree and from grove to grove. When a bird alights on a dead twig its feet may come in contact with the sticky exuding spores which will be carried to other dead wood in uninfected localities. The fungus also produces spores on rotten and mummified fruits on the ground.

Melanose starts on the leaves and shoots only when there is a new growth. On the fruit it may start from the time after the petals fall and continue until late summer or early fall.

Dead wood in a tree is a great source of infection for other parts of the tree and for other trees in the grove that are uninfected with melanose disease. In order to control the disease, all dead wood in the trees should be pruned out and burned. Such pruning should be done systematically from year to year so that dead branches are not allowed to hang on the tree. Pruning should preferably be done during the dormant season, but if it must be done during the growing season it should be done after the first growth has hardened in June or July.

Protection from infection can be secured by spraying with Bordeaux mixture, ammoniacal copper-carbonate solution or lime-sulphur solution. At least two sprayings should be made, the first soon after the bloom drops and the second 3 weeks to 1 month later. A large increase of scale insects is likely to follow the use of either the Bordeaux or ammoniacal solution of copper carbonate, so that it will be necessary to spray with some good insecticide to keep down the scale insects. If scale insects are prevalent an insecticide should precede the use of the fungicide. All dropped or rotten and mummified fruits under the trees should be destroyed. It is important to avoid clipper cuts and bruises of all kinds on the fruit, because such abrasions are particularly liable to become infected with the disease.

10. Stem-End Rot.—The fungus that causes melanose is also responsible for another disease known as stem-end rot. The disease may be found on all varieties of citrus, where it causes a decay mostly of the interior of the fruit just before or after it is mature. Stem-end rot attacks fruits while they are on the tree and causes them to drop and rot just before they are mature. The disease also causes a softening and rotting of citrus fruit in transit to market or soon after its arrival at the market.

The disease may sometimes appear in the grove early in the fall. It manifests itself on the fruit as a dark or reddish brown to almost black discoloration about the stem end. The discoloration may sometimes be found on fruit hanging on the tree, especially on affected tangerines; sweet oranges and grapefruit are more apt to drop off before the discoloration begins to show. Twigs from which infected fruit has dropped sometimes die back a short distance and show drops of gum at the junction of the live and dead tissue. Spores of the fungus are produced in abundance on these dead twigs.

The disease manifests itself on mature packed oranges as follows: A circular area around the stem becomes soft, without at first any apparent discoloration of the rind. As the softening progresses the affected rind becomes dull brown, drab, or coffee colored. When the fruit is opened the decay will be seen to have advanced most rapidly along the center where the segments meet and into the inner white part of the peel and less rapidly into the juice sacs. The decay is usually accompanied by the exudation of a small quantity of amber-colored sticky juice. Fig. 7 shows a section of a grapefruit affected with stem-end rot. Notice the ring of scale insects about the stem and the wrinkling of the skin.

The development of stem-end rot on the fruit depends to a great degree on conditions that tend to weaken the fruit or that aid the fungus in gaining an entrance at the stem end. The presence of scale insects at the stem of the fruit, abnormally warm weather after the fruit is mature, and low, moist situations appear to favor the development of stem-end rot. The scale insects crawl under the calyx of the fruit and weaken it, while

warm weather and moisture encourage the development and growth of the fungus causing the decay.

Methods of control for stem-end rot are very similar to the methods of control practiced for melanose. Spraying with Bordeaux mixture has not so far proved effective for the control of the stem-end rot. A spray of this kind kills the fungi that are parasitic on the scale insects and as a result the scale insects increase and render the fruit even more susceptible to stem-end rot.

FIG. 7

Pruning out dead wood as described under melanose, destruction of all dropped fruit, care in avoiding injuries on the fruit, culling out all defective fruit, and spraying to keep scale insects in check are the preventive measures to be used for the control of this disease.

11. Diplodia Rot.—In many respects diplodia rot is very similar to stem-end rot. The fungus causing diplodia rot does not attack citrus fruits in Florida so readily as does the fungus causing stem-end rot and usually requires a more serious injury in the fruit for its entrance. This fungus or one very similar in nature has been reported in South Africa, where it causes a very serious decay in lemons. The fungus causing the diplodia rot often starts in punctures in the rind of the fruit or in other small wounds. The disease in its earlier stages manifests itself by a discoloration about the stem end of the fruit, similar to the discoloration caused by the stem-end rot. As the decay of the fruit proceeds the discolored area becomes darker in color and appears as dark, wide bands, giving the surface of

the fruit an appearance that is very similar to the division between segments. The fruit becomes black as the decay advances and becomes light in weight. The rot often advances rapidly through the flesh to the blossom end and a small discoloration shows there before all the peel is involved.

The disease is usually accompanied by the exudation of a small amount of thin gum or a considerable amount of amber-colored sticky juice. There is a larger amount of juice exuded when this disease is present than is caused by the stem-end rot disease.

Diplodia rot can be controlled by the same methods that are practiced for the control of stem-rot end.

12. Blue and Green Mold Decay.—The blue and green molds are frequently the causes of decay of citrus fruit that is being held in storage or while it is being transported from one place to another. These diseases are due to two closely related fungi; the blue mold is more active than the green mold. Fruits affected with these diseases first become soft in a small area. The infected area enlarges rapidly and becomes covered with a white mold, which is followed by a mass of green spores over the mold if the green mold is present or blue spores if the blue mold is present. These spores arise in a cloud of dust if the fruit or mold is disturbed. Fig. 8 shows an orange affected with blue mold.

Experiments carried on by the United States Department of Agriculture have demonstrated that decay from mold is confined almost entirely to fruit that is bruised or otherwise injured in handling. The mold fungi are unable to penetrate the skin of sound fruit. Therefore, growers and packing-house employes should take every precaution to avoid bruising the fruit. Long stems should not be allowed to remain on the fruit, as this is often a cause of bruising; clipper cuts should be avoided in removing the fruit from the tree. Care should be taken that the fingernails do not scratch the fruit when it is handled. Bruises from pouring the fruit into field boxes and jostling of the fruit over a rough road in wagons without springs should be avoided. Care should be taken that the boxes in which the fruit is placed do not have splinters and rough edges, as this is

frequently a source of injury to the fruit. Not only must the slight injuries to the fruit be avoided but the field boxes, wagons, packing houses, and machinery should be kept clean and free from undue contamination with the mold spores from rotting fruit lying around.

13. Black Rot.—Black rot is a disease of oranges that is not common in the gulf-coast states but is common in certain parts of California where navel oranges are grown. The disease is due to a fungus that enters through the navel end of the fruit

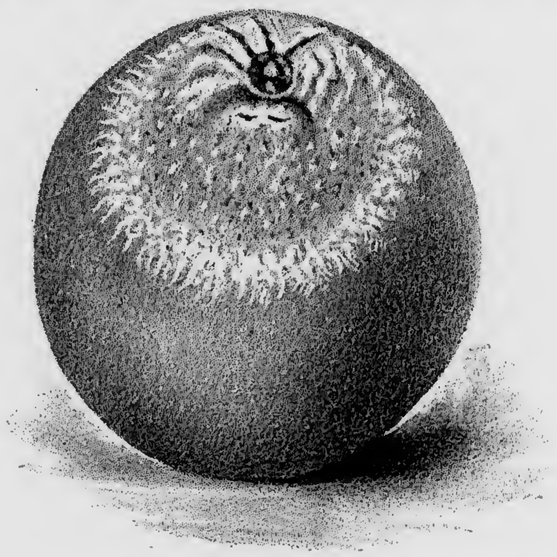

FIG. 8

while it is developing. However, the disease has been observed in Florida on varieties of fruit other than navels, and seems to have found entrance to the fruit through slight defects at the blossom end. The disease will cause small green fruit to exude a drop of gum at the navel or blossom end of the fruit, to turn yellowish, and drop off.

The rot is most often noticed just before healthy fruit colors. The fruit infected at this time turns a deep orange color and has the appearance of ripening prematurely. If this diseased fruit is cut open it will be found to have a black decayed center, principally along the core. This decay does not cause the fruit

to soften so rapidly as some of the rots. In Fig. 9 is shown a fruit infected with black rot.

The disease does not usually attract enough attention to call for remedial measures. Only a small percentage of the fruit is attacked. It would seem to be a wise measure to destroy the dropped affected fruit.

14. Maldigoma.—Throughout Florida and the gulf-coast states maldigoma, or *foot rot*, is a disease that is very common, especially on old seedling trees. The symptoms of the disease are abundant exudations of gum on the trunk of the tree near the surface of the ground. Close examination will show that the bark has been killed about the point of infection. The inner bark and finally the wood underneath becomes rotten and often has a very disagreeable fetid odor. The infection spreads in all directions, mostly down on the main crown roots and laterally around the trunk, sometimes completely girdling the tree. As the infection spreads the bark dies, breaks away in patches, and leaves bare dead areas that extend in all directions. Trees affected bear heavily and the leaves become yellow.

FIG. 9

Improper drainage, too close planting, deep planting, and continuous excessive irrigation are conditions that seem to favor the development of foot rot. For this reason care should be taken that these conditions do not exist in a citrus grove. Fortunately foot rot may be almost entirely prevented by budding nursery trees on sour-orange roots. The different varieties of citrus stocks appear to stand in order of foot-rot resistance about as follows: sour orange, pomelo, rough lemon, lemon, sweet

orange. Many trees infected with foot rot, if taken in time, can be cured by digging away the soil and exposing and drying the crown roots. The decayed areas should be cut away and the remaining portions cleaned and disinfected. However, cutting away of the disease areas and drying of the remaining portions is of more importance than the disinfecting. A great many disinfectants have been used with good results. Some of these are a thick Bordeaux mixture or paste made with 1 pound of bluestone, 2 pounds of rock lime, and 6 quarts of water; crude carbolic acid and water at the rate of 1 part carbolic acid to 3 parts of water; sulphurous acid, 1 part, water 6 parts, and Avenarius carbolineum 1 gallon, in which 1 pound of whale oil soap is dissolved. Foot rot appears to be contagious and for this reason great care should be taken that the instruments employed in work about diseased trees be disinfected before they are used about healthy trees.

FIG. 10

15. Psorosis. The disease known in California as scaly bark is known in Florida as psorosis. It has sometimes been confused with the disease known in Florida as scaly bark or nail-head rust, but it is a different disease. The disease is characterized by the bark being pushed up and broken into pieces over areas 2 inches to a foot or more in length. These areas assume a shaggy, ulcerated appearance. Fig. 10 is a branch showing the bark broken in flakes due to this disease. The diseased area may extend entirely around a tree trunk or a large limb, or it may be confined to one whole side or to comparatively small areas. Fig. 11 is an orange tree showing definite areas on the trunks affected with psorosis.

Small drops of gum which are exuded mostly during the growing period accompany the disease. During the fall and winter the gum usually ceases to form on the exterior.

Sweet-orange trees appear to be especially subject to this disease. In California the navel orange is somewhat more subject to it than the Valencia orange. The cause or causes of psorosis are as yet obscure. In California it has been thought that extreme changes in moisture conditions of the soil is a contributing factor to its occurrence. It is likely that some obscure semiparasitic organism may contribute to its occurrence. The treatment recommended for this disease is: first, to dig out and replace the worst affected trees; second, to remove all branches that are infected; third, to cut out small infected areas on the trunk to healthy bark and treat the wound with Bordeaux paste or some other non-injurious fungicide.

FIG. 11

16. Scaly Bark.—Scaly bark, or *nail-head rust*, is frequently confused with psorosis, but it is a different disease.

The Florida scaly bark disease is not known to exist in California. Scaly bark is a very destructive disease, because in its severe stages it not only covers the tree with ruptured bark, including the trunk, branches, and twigs, but also spots the fruit and causes it to drop before it is mature. The scaly-bark disease manifests itself on the smooth bark of branches 6 to 9 months old and older by round or oval spots $\frac{1}{6}$ to $\frac{1}{2}$ inch in diameter, as shown in Fig. 12. These are rusty in color, with well-marked edges, and are raised above the surface of the bark. As the infected spots grow older the bark becomes glazed, then brittle, and finally cracks lengthwise through the diseased area. Finally the bark breaks into small flakes, or scales. When the spots are numerous they run together, forming large patches of scaly bark accompanied by small drops of gum. On the larger limbs, and sometimes on the trunk, patches of rough scaly bark can be seen. If the hand is passed over these diseased areas small pieces of the bark will scale off.

FIG. 12

On the fruit the disease is characterized by brown sunken spots, some of which are apt to be in the form of rings. Fig. 13 gives a good idea of the way the scaly-bark disease affects the orange. The ringed areas are very pronounced in the illustration. The infected spots are yellowish to reddish brown in color, on the green fruit, and finally become dark and sunken. The spots are from $\frac{1}{5}$ to $\frac{1}{2}$ inch in diameter.

17. The method used to control scaly bark, or nail-head rust, depends to a large extent on the stage of the disease, the

age of the trees, and according to whether temporary relief or permanent results are sought.

If permanent results are sought the diseased trees can be top grafted. Grapefruit, Mandarin oranges, and tangerines are nearly immune to infection from this disease even when surrounded by badly diseased sweet-orange trees. For this reason varieties of citrus trees that are susceptible to this disease may be topgrafted with varieties that are not so readily susceptible to the disease. The large limbs may be removed during December and January, as is practiced for top grafting. If the grafts fail to take, the sprouts from the limbs may be budded later. If one does not wish to be constantly removing sprouts from the lower part of the tree, the trunk may be sawed off near the ground and grafted. This method will require a year or two longer to secure a tree in good bearing.

FIG. 13

If it is not desirable to bud over to immune varieties, there are other methods that may be employed with good results, but with less certainty of permanent success. During December and January the trees should be headed back by cutting out the top. The trunk and the larger branches should be allowed to remain. The trees should then be sprayed thoroughly with Bordeaux mixture prepared according to the following formula: 5 pounds of rock lime, 5 pounds of bluestone, and 50 gallons of water. Three or four sprayings should follow throughout the season at intervals of 8 weeks as new growth comes on. The increase of scale insects following the application of the fungicide will have to be checked by an insecticide. Fig. 14 (*a*) shows a characteristic scaly bark branch unsprayed; in (*b*) is shown a branch taken from a tree near by the tree from which the scaly bark branch was taken, that has been sprayed twice with Bordeaux mixture. The contrast of the sprayed and the

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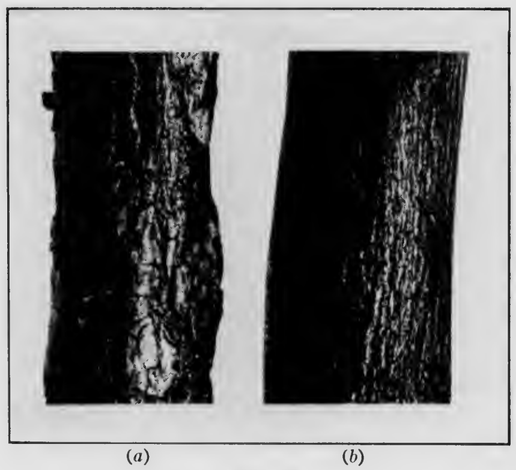
unsprayed branch is very apparent in the illustration. In Fig. 15 is shown an orange tree that has been headed back and sprayed six times with Bordeaux mixture at intervals of about 2 months. In Fig. 16 is illustrated another tree near by that was headed back but not sprayed. From the illustration it can be plainly seen that there is a decided advantage in spraying trees with Bordeaux mixture as a preventive against infection of scaly-bark disease.

Since infection of fruit and new wood comes from old dead wood, much good can be accomplished by pruning out the dead wood thoroughly. The badly diseased limbs should also be pruned out thoroughly.



(*a*) (*b*)

FIG. 14

18. Diplodia Gumming.—The fungus causing diplodia gumming attacks all kinds of citrus trees, but the pomelo tree is most susceptible to its attack. The fungus probably enters the tree through wounds or injuries in the bark.

The disease manifests itself by the oozing of gum through cracks in the bark, usually on the branches as shown in Fig. 17. In severe attacks the wood on the larger branches is blackened and areas of the bark die. The disease frequently extends in the wood much beyond any external sign on the bark. When smaller limbs are affected they are often killed back to some extent and numerous black spore pustules push up through the bark.

The method for the control of the disease as used in Florida is: (1) To cut out the most badly diseased limbs; (2) to cut out the diseased area as it begins to form on one side of the larger limbs; (3) to cut out the smaller affected branches entirely.

19. Citrus Canker.—The disease known as citrus canker has only recently been described by Prof. H. E. Stevens, plant pathologist of the University of Florida. It is of recent introduction in the gulf-coast states and thus far has been found in

FIG. 15

Northern and Southern Florida and in Alabama; it is also said to be in Texas. The indications are that if the disease once becomes well established it may become a serious menace, especially to the grapefruit industry. So far in Florida the disease has been found only on nursery stock, principally on

grapefruit. Infections have been observed on Citrus trifoliata and on the Satsuma orange, but the latter seems to be fairly resistant. The sweet orange is apparently not affected. The disease manifests itself on the leaves, young shoots, twigs, and

FIG. 16

fruit of the pomelo as small circular spots from less than $\frac{1}{16}$ to $\frac{1}{4}$ inch in diameter. The spots may occur singly or several may coalesce and form an irregular area. The spots are raised above the surrounding tissue, are light brown in color, and are composed of a spongy mass of dead cells covered by a thin white to

grayish membrane, which finally ruptures and turns outwards, forming a ragged margin around the spot. The general appearance of the spots is much the same whether they are found on leaves, twigs, or fruit.

The spots on the leaves appear in their early stages as watery, bulging dots, which are usually of a darker green than the surrounding tissue. These spots may be found on either surface of the leaf, but they do not penetrate through the leaf tissue at this stage. As the infection spreads the spots gradually increase in size and change to a light-brown color and become visible on both sides of the leaf. The spot may project from the surface on one or both sides of the leaf. Each spot is surrounded by a narrow yellowish band, or zone. Later the surface of the spot becomes white or grayish and ruptures, exposing a light-brown, spongy central mass.

FIG. 17

The spots on the fruit are very similar to those on the leaves. They project from the surface of the skin and are circular in outline. The spots do not penetrate far into the rind; they may occur singly over the surface of the fruit or may coalesce, forming an infected area that is irregular in outline.

On the older twigs the spots are more prominent and usually larger and more irregular in outline than those on the leaves. They have the same spongy nature and the same color as those on the leaves. On branches more than a year old the infection assumes a cankerous nature and the membrane covering the surface of the infected area disappears. The infection

does not penetrate to the wood, but is confined to the outer tissue of the bark.

Citrus canker may be confused with scaly bark, scab, and anthracnose. However, it differs from scab in that the spots are more round, and are larger in size; the spots are white or gray in color, and the leaves are not distorted or covered with wartlike projections, as is common in an infection of scab. Citrus canker differs from scaly bark in that the spots are not so large and are more circular in outline. Also, the infected areas are spongy, whereas scaly-bark spots are usually hard and glazed in appearance. Spotting due to citrus canker differs from spotting due to anthracnose in that anthracnose spots are sunken and are usually many times larger and much firmer and more compact. Also, anthracnose occurs only on the fruit and does not attack the twigs.

The organism causing the disease has not been determined, but it is probably due to a fungus. The disease is infectious, as has been shown by the results of some experiments. The disease developes rather slowly, but when a spot once forms it becomes a center from which infection spreads to surrounding tissue.

20. Citrus canker when once introduced into a locality, may be expected to spread rapidly. For this reason preventive measures against the disease are most important. The introduction of infected nursery stock in either new or old groves should be avoided. Only young trees that are known to be free from disease should be planted. Young groves should be inspected from time to time for the appearance of the disease. The diseased areas develop in early spring or throughout the summer, but they will be more prominent in late spring and in autumn. If infected trees are found they should be removed and burned without delay. Trees 2 or 3 years old may be cut back severely, just enough being left to save the bud; the material cut away from the tree should be burned. When large trees are affected all diseased parts should be pruned out and burned. The part of the tree that remains and also neighboring trees should receive an application of Bordeaux mixture every 2 weeks until all further development of the disease ceases.

PHYSIOLOGICAL DISEASES

21. Blight.—Blight, also sometimes known by growers as *wilt*, is the most dreaded citrus disease, because nothing is definitely known as to its cause. A large amount of scientific study and investigation has been given to this disease, without

FIG. 18

so far finding anything that could satisfactorily explain the cause of the trouble.

The first symptom of blight is usually a wilting of the foliage as if the tree was suffering from drought. Most often this symptom occurs in early spring and at first appears most pronounced on dry, hot days, but later the wilting continues through damp, wet weather. Most often a single limb near the top will

show signs of wilting, and the wilting will spread to the other branches. As the disease progresses the leaves often drop off, or in some cases the wilting may occur so suddenly that the dry leaves will remain hanging to the twigs. After the top has been injured numerous water sprouts grow out from the trunk and large limbs. These at first appear healthy and seem to promise a new, healthy tree, but after a time they become sickly in appearance and later die. Fig. 18 shows a blighted orange tree. The dead branches and the suckers growing out from the base of the tree are very apparent in the illustration. Trees of any age may be attacked, but as a general thing the trouble appears most commonly in old bearing trees. The disease may frequently suddenly attack the largest and most productive trees in a grove. Up to the time the trees are attacked they appear to be healthy. No external agent has been found associated with the disease. Trees growing on light hammock soil appear to be more susceptible to the disease, although it may appear on trees growing on other soils. In some respects the disease acts somewhat like peach yellows, a disease the cause of which is not yet known.

FIG. 19

Pruning does not check the progress of the disease. Diseased branches may be removed, only uninfected branches being left, yet the disease will reappear. Since in most cases of blight the roots appear to be healthy, it was thought that by growing new tops on the blighted trees the disease could be controlled. Much time has been wasted without results. Attempts have been made to move the blighted trees to different soil after the tops were cut back. For 2 to 3 years such trees grew out and gave promise of recovering, but later the top sickened and died back as before. The best suggestions that can be made regarding the control of this disease is to dig out and burn diseased trees as fast as they show the symptoms of blight. It is important that the roots in the soil be burned as well as that part of the tree that is above the ground. Roots of affected trees allowed to decay in the ground may be a means of spreading the disease through the soil.

22. Exanthema.—Exanthema, or *die-back*, is a common disease of citrus trees. In Florida it is largely known as die-back and in California it is known as Florida die-back. It is not due to any fungous or bacterial organism, but is thought to be due to improper feeding conditions. Exanthema has a great many different symptoms by which it can be recognized. Prof. B. F. Floyd, of the Florida Experiment Station, has given the following symptoms by which the disease may be recognized: (1) gum pockets in the wood of the young angular stems; (2) staining of the leaves and bark of young terminal stems while they are maturing; (3) exudations of gummous cortical tissue through a break in the bark; (4) multiple buds; (5) ammoniated fruits, which is a term used to designate fruits whose epidermal and sub-epidermal tissues are stained as a result of die-back; (6) gum in the angles of the pulp segments of the fruit; (7) abnormally thick rinds on the fruit.

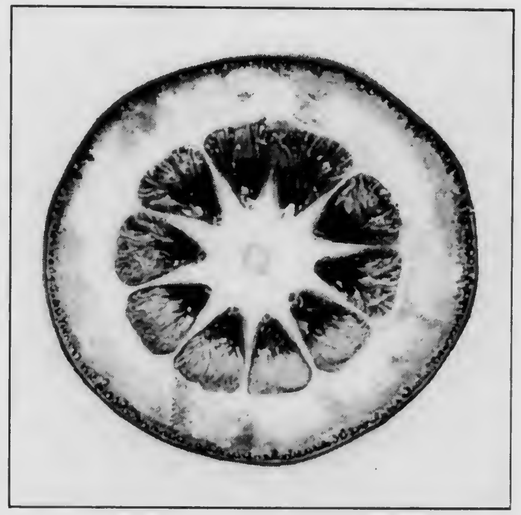


FIG. 20

In Fig. 19 the staining on the epidermis of the lemon can be plainly seen. In Fig. 20 the abnormally thick rind of the fruit and the gum in the angles of the pulp segments can be seen.

The disease is closely associated with the following conditions: (1) excessive applications of organic nitrogenous fertilizers, such as stable manure, dried blood, cottonseed meal, etc.; (2) unfavorable soil conditions, such as lack of drainage, or compact soil of hardpan, clay, or marl too near the surface.

The removal of the causes that aggravate the disease usually results in a complete recovery of the tree. If the disease has been brought on by too much organic nitrogenous fertilizer, the mineral fertilizers, such as nitrate of soda, nitrate of potash or sulphate of ammonia, should be substituted. No cultivation should be given except what is necessary to conserve moisture. The natural growth of grass and weeds during the rainy season may be cut and removed until the trees recover. One to several seasons may be required for complete recovery. If the disease has been due to unfavorable soil conditions, such as a layer of hardpan too near the surface, this may be broken up, either with subsoiling implements or dynamite, depending on the thickness. Lack of drainage should be corrected either by ditches or some form of artificial drainage. Spraying with Bordeaux mixture has sometimes been found beneficial against this disease, probably because of its stimulating effect on the trees.

FIG. 21

23. Frenching.—A yellowing of the leaves between the veins is known in Florida as frenching and sometimes as chlorosis; in California the same effect is known as mottled leaf. Fig. 21 shows the characteristic yellowing known as frenching. It is not a definite disease but only a symptom of something wrong due to improper nutrition of the tree. It may be brought on by improper soil, fertilizer, moisture, or other conditions.

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NOTE.—All items in this index refer first to the section (see the Preface) and then to the page of the section. Thus, "Basin irrigation, §22, p15," means that basin irrigation will be found on page 15 of section 22.

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